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The Engineer

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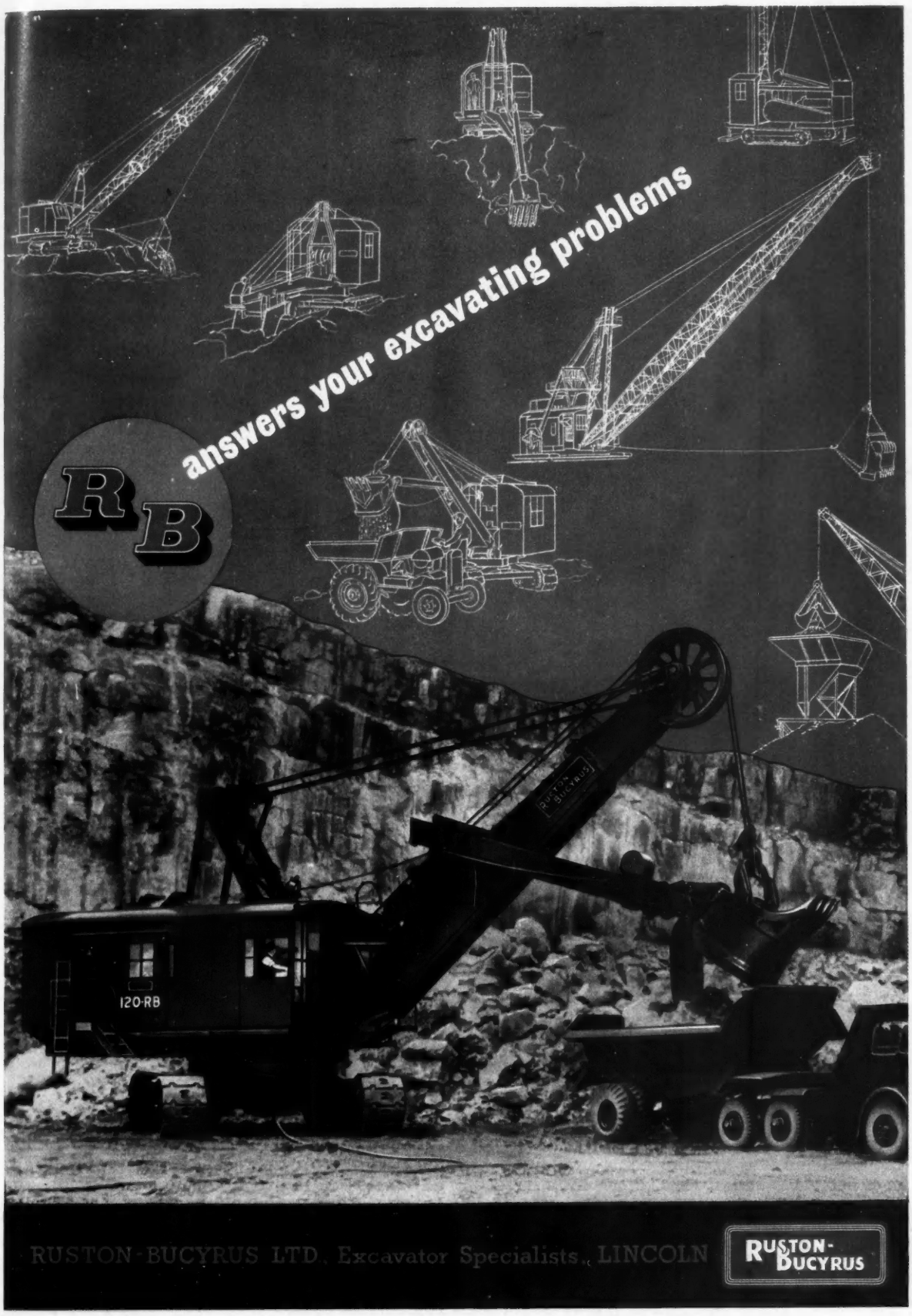

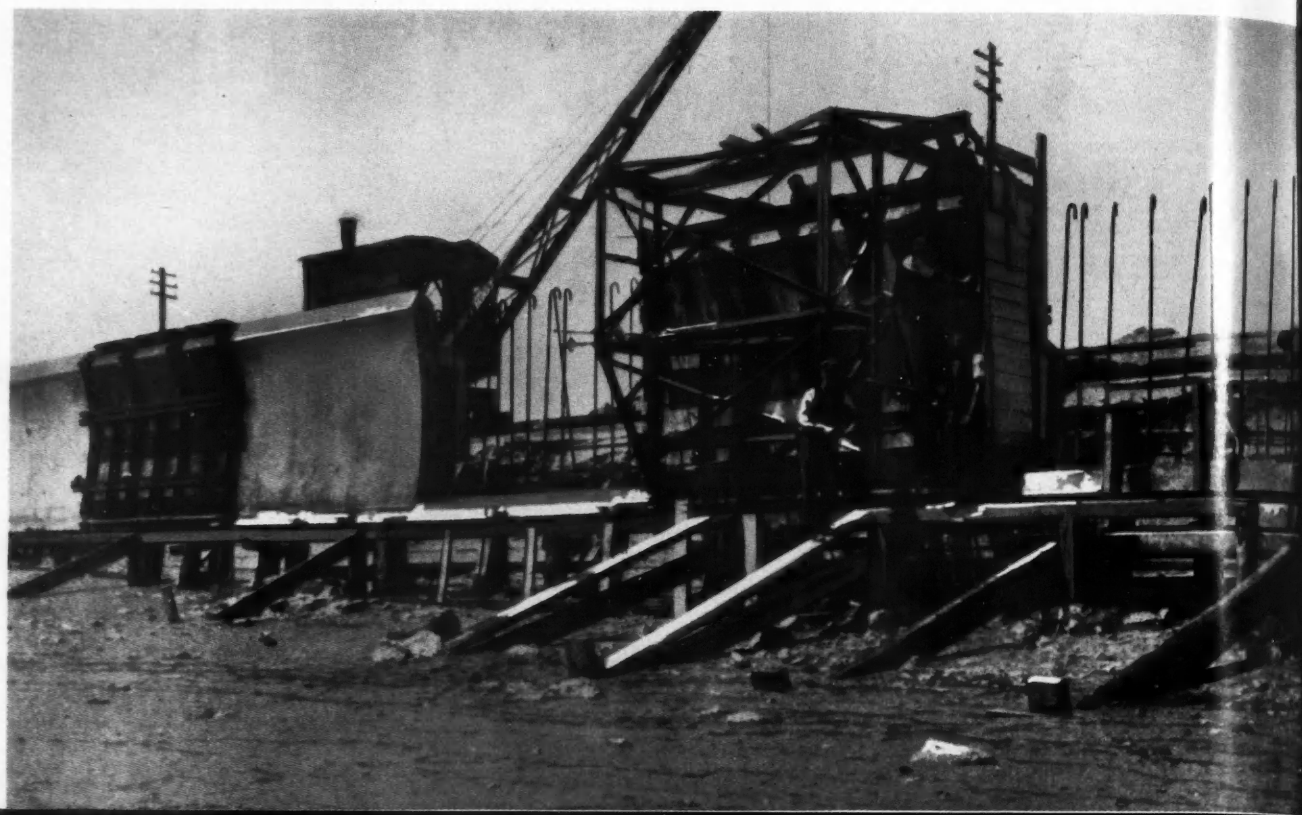

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Wickman

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EIGHT SPINDLE AUTOMATICS
provide production engineers with
w opportunities to increase output
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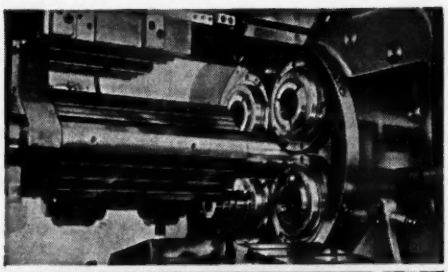
4 SPINDLES 3¼" bar capacity



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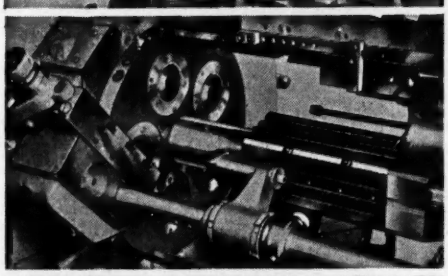

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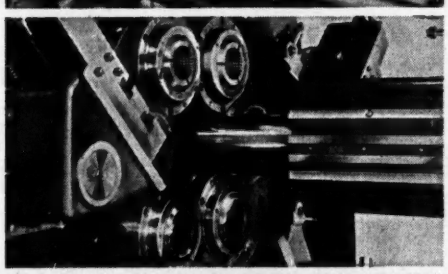

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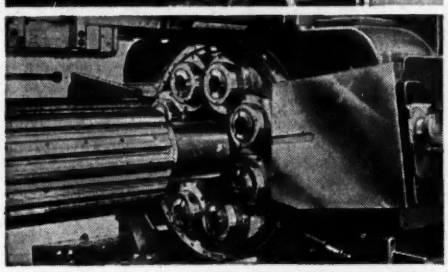
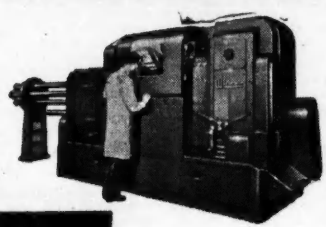


producing Wickman Multi-spindle matics can now be applied to a wider e of jobs than ever before. The man patent auto-setting mechanism is porated in all machines of the range lterations to tool feed strokes and bar re accomplished without cam changing.



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WM280

THE ENGINEER

ESTABLISHED 1856

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MAY 15, 1953

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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WORDING OF ADVERTISEMENTS: Approximately the first 25 letters of each advertisement are set in heavy type. Advertisers are therefore advised to begin their advertisements with the words they want emphasized.

Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

THE UNIVERSITY OF LIVERPOOL

DEPARTMENT OF MECHANICAL ENGINEERING

ASSISTANT LECTURER OR LECTURER

Applications are invited for the post of ASSISTANT LECTURER or LECTURER in the Department of Mechanical Engineering. The initial salary for an Assistant Lecturer will be £450 per annum, with allowance for age, experience and qualifications; the initial salary for a Lecturer will be within the range £550–£800 per annum, according to qualifications and experience.

Applications stating age, academic qualifications and experience, together with the names of three referees, should be received not later than 6th June, 1953, by the undersigned, from whom further particulars of the conditions of appointment may be obtained.

STANLEY DUMBELL,
Registrar.

May, 1953. E8663

NORTHAMPTON POLYTECHNIC, ST. JOHN STREET, LONDON, E.C.1

CIVIL AND MECHANICAL ENGINEERING DEPARTMENT

ASSISTANT LECTURER (GRADE B)

Applications are invited for the following appointment in the Civil and Mechanical Engineering Department.

ASSISTANT LECTURER (Grade B), to teach Civil Engineering subjects in Degree and National Certificate Courses. Ability to undertake classes in surveying and soil mechanics would be an advantage. Applicants should be Graduates in Engineering with some professional experience.

Salary in accordance with the London Technical Burnham Scale, Grade B, viz., £490 by £25 to £765, with allowance of £60 for graduates or equivalent, and up to £54 for training, plus London allowance of £36 (£48 if over 37).

Further particulars and form of application are obtainable from the Secretary, to whom applications should be sent as soon as possible.

J. E. RICHARDSON,
Ph.D., B.Eng., M.I.E.E.,
Principal.

E8509

WOOLWICH POLYTECHNIC, LONDON, S.E.18

Principal: J. S. TAIT, Ph.D., B.Sc., A.R.T.C., M.I.E.E., A.M.I.Mech.E.

HEAD OF THE CIVIL AND MECHANICAL ENGINEERING DEPARTMENT

The Governing Body invite applications for the post of HEAD of the CIVIL and MECHANICAL ENGINEERING DEPARTMENT.

The Department prepares students for the B.Sc. Engineering Degrees as Internal Students of London University, and National Certificates in Mechanical, Civil and Production Engineering.

Salary scale: Grade IV under the Burnham Technical Award, viz., £1340 by increments of £25 to £1490 per annum (plus London allowance £36 to £48 per annum).

Full particulars of the post and application forms may be obtained from the Clerk to the Governors, to whom they should be returned not later than 6th June, 1953. E8600

AIR MINISTRY

ROYAL AIR FORCE TECHNICAL CADETSHIPS

Young men between 17 and 19½ years on 1st July, 1953, are invited to apply for TECHNICAL CADETSHIPS leading to Permanent Commissions in the Technical Branch of the Royal Air Force and offering excellent prospects of promotion to higher rank.

There are two kinds of Technical Cadetships as shown below.

University Cadetships: candidates must be educationally qualified for University entrance and possess a General Certificate of Education with passes at Advanced Level in Physics and Mathematics, or a Scottish Leaving Certificate with Higher Grade Passes in these subjects, or have an equivalent qualification. Successful candidates are first given a year's preparatory training as Officer Cadets at the R.A.F. Technical College, Henlow. They are then commissioned and are sent to a University for a three years' Honours Degree course in Science or Engineering. Provided they are medically fit they learn to fly with the University Air Squadron. Pay during training starts at 7s. per day. During the University Course the Service pays all fees as well as board and lodging allowances, and at the same time pay is increased to 12s. a day, rising to 17s. 6d. On graduation, cadets become Permanent Officers of the Technical Branch and will have opportunities of rising to air rank, at which basic salaries range from £1551 to £2738 a year. On retirement they will qualify for a terminal grant of £1000 and retired pay.

Henlow Cadetships: candidates must possess a General Certificate of Education with passes at Ordinary Level in English Language and two other subjects, and also passes at Advanced Level in Physics and Mathematics, or an equivalent Scottish Leaving Certificate or other equivalent qualification. Successful applicants will spend three years as Officer Cadets at R.A.F. Technical College, Henlow, where they will be trained in Mechanical or Electrical Engineering to the standard of the Higher National Certificate. During this training pay rises from 7s. to 9s. 6d. a day, food, lodging, &c., being provided. On successful completion of the Henlow course cadets become Permanent Officers of the Technical Branch with career prospects similar to those of University Cadets. Entries for Cadetships under both schemes close on 1st June, 1953.—For further particulars write to Air Ministry, A.R.1 (J.4), Adastral House, Kingsway, W.C.2. E8212

PUBLIC APPOINTMENTS

SUNDERLAND EDUCATION COMMITTEE

THE TECHNICAL COLLEGE

Principal: D. A. WRANGHAM, M.Sc. (Lond.), Sen.Wh.Sch., A.C.G.I., D.I.C., M.I.Mech.E.

ASSISTANT LECTURER IN MECHANICAL ENGINEERING

Applications are invited for the post of ASSISTANT LECTURER IN MECHANICAL ENGINEERING in the Engineering Department. Candidates should possess a Degree in Mechanical Engineering and have industrial experience. Some teaching experience is very desirable. The work of the Department includes courses for the B.Sc. Degrees of Durham and London Universities, and the Higher National Diploma and Certificate in Mechanical Engineering.

Duties to commence 1st September, 1953.

Salary in accordance with the Burnham Technical Scale, Grade "B," £490 by £25 to £765. Increases above the minimum will be allowed for industrial experience, training and Degree.

Forms of application and further particulars may be obtained from the Registrar, Technical College, Sunderland, Co. Durham.

Applications should be returned to the undersigned not later than 21st May, 1953.

Canvassing will be a disqualification.

W. THOMPSON,
Director of Education.

Education Offices,
15, John Street,
Sunderland. E8517

THE ROYAL TECHNICAL COLLEGE, GLASGOW

(IN AFFILIATION WITH THE UNIVERSITY OF GLASGOW)

DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING

LECTURESHIPS AND ASSISTANT LECTURESHIPS

Applications are invited for LECTURESHIPS and ASSISTANT LECTURESHIPS in (a) Applied Mechanics, in (b) Heat Engines, and in (c) Engineering Drawing. Candidates should have a good Honours Degree and industrial experience; teaching experience an advantage.

The Engineering Courses are conducted on a sandwich system which leaves the summer term free for research, opportunities for which are exceptionally good.

Salary on scale: Lecturer, £600 × £50–£1150; Assistant Lecturer, £500 × £25–£600.

Forms of application can be had from the Secretary of the College. E8596

WILTSHIRE COUNTY COUNCIL

NORTH-WEST WILTS AREA COLLEGE OF FURTHER EDUCATION, CHIPPENHAM SECTION

Applications are invited for the following posts:—

(i) ASSISTANT TEACHER, Grade "B" to commence duties September, 1953, with production engineering qualifications, capable of teaching metrology and machine tools and workshop technology to H.N.C. and City and Guilds machine shop engineering to Final Standard. Applicants should have suitable qualifications, industrial and teaching experience or training.

(ii) WORKSHOP MECHANIC / STOREKEEPER, ELECTRICAL FITTER, to commence duties 15th August, 1953. Applicants must be in possession of the City and Guilds Final Machine Shop Engineering Pass or Higher National Certificate. Salary will be in accordance with the Joint Negotiating Committee for Local Authorities Service (Engineering Craftsmen), 3s. 6d. per hour for a forty-four-hour week, day and/or evening.

Application forms and further details can be obtained from the Principal of the College, Cocklebury Road, Chippenham, Wilts.

K. S. INNES,
Director of Education.

E8643

HER MAJESTY'S COLONIAL SERVICE

PUBLIC WORKS DEPARTMENT, TANGANYIKA

ASSISTANT ENGINEERS

Applications are invited for the following posts:—

ASSISTANT ENGINEERS, Public Works Department, Tanganyika.

Appointment is on probation for permanent and pensionable establishment. Salary in incremental scale £655–£1320 p.a., plus temporary, variable, non-pensionable cost-of-living allowance at the rate of 30 per cent. of salary, subject to maximum of £300 p.a.

Candidates must hold a recognised University Degree or Diploma in Civil Engineering, carrying exemption from Sections I and II of the A.M.I.C.E. examinations, and have had at least two years' approved practical experience, or be A.M.I.C.E. Duties will include surveys, reports, designs, specifications for civil engineering works, and administration organisation and supervision of the construction and maintenance of such works.

Full details on application.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number CDE 112/8/03. E8608

PUBLIC APPOINTMENTS

HER MAJESTY'S COLONIAL SERVICE

PUBLIC WORKS DEPARTMENT, FIJI

EXECUTIVE ENGINEER

Applications are invited for the following post:—

EXECUTIVE ENGINEER, Public Works Department, Fiji.

Appointment is permanent and pensionable. Salary £F1350 × £F50–£F1450 p.a., plus temporary variable non-pensionable cost-of-living allowance of 10 per cent. of salary up to a maximum of £F130 p.a. (£Stg. 100 = £F111). Candidates must hold a recognised University Degree or Diploma in Civil Engineering carrying exemption from Sections I and II of the A.M.I.C.E. examinations, or be A.M.I.C.E., and have had considerable practical experience, preferably in the Colonies. Duties will include taking executive charge of a public works district, and experience in maintenance and construction work in buildings water supply, roads, including operation of quarries and heavy road plant, wharves, &c., and control of works and clerical staff is essential.

Full details on application.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number CDE 112/49/02. E8607

CENTRAL ELECTRICITY BOARD

FEDERATION OF MALAYA

ASSISTANT POWER STATION SUPERINTENDENT

ASSISTANT POWER STATION SUPERINTENDENT required, with option of appointment either (a) on agreement for 3 years in the first instance, leading, subject to satisfactory service, to an offer of permanent employment on the pensionable establishment, with opportunity of terminating appointment at the end of first year's service if desired, or (b) on contract for three years with gratuity of £200 or £280 for each years' service according to salary. Free passages and liberal leave on full salary. Salary, &c., equivalent to £1904, rising to £2730 a year. Candidates must have wide experience of station maintenance and operation and preferably have held a similar position in a steam power station of not less than 80MW capacity, or as a charge engineer for at least 5 years in a station of not less than 120MW capacity.—Apply in writing to the Crown Agents, 4, Millbank, London, S.W.1, stating age, name in block letters, full qualifications and experience, and quoting M2C/28769/EH. E8583

THE CEYLON FIRE INSURANCE ASSOCIATION

ASSISTANT INSPECTOR

The Ceylon Fire Insurance Association invite applications from Junior Engineers for the post of ASSISTANT INSPECTOR. Applicants should be about 30 years of age. They must be technically qualified, holding not less than the Ordinary National Certificate in Electrical Engineering or its equivalent, and have received a comprehensive general engineering apprenticeship in the electrical/mechanical fields. Practical experience in the wiring of buildings for both power and lighting installations, together with a good working knowledge of the I.E.E. Wiring Regulations essential. The work is chiefly connected with the inspection and preparing of reports on the condition of electrical/mechanical and fire-extinguishing equipment in tea factories. Application forms and details of terms of engagement from the Secretary, Fire Offices' Committee (Foreign), 65, Watling Street, London, E.C.4. E1660

DOCKS AND INLAND WATERWAYS EXECUTIVE

NOTTINGHAM–GRANTHAM DISTRICT

SITE ENGINEER OR SURVEYOR/ESTIMATOR

SITE ENGINEER or SURVEYOR/ESTIMATOR required in the Nottingham–Grantham District Must have experience in taking off, measuring up and preparing estimates of cost for civil engineering work connected with drainage and water supply. A good knowledge of instrument work and ability to prepare surveys is essential. The post is temporary and is for a period of at least one year at a salary of £600 per annum.—Apply, stating age and experience, to the Divisional Engineer, Docks and Inland Waterways Executive, Dock Street, Leeds, 1. E8628

BOROUGH OF MANSFIELD

WATER DEPARTMENT

The Borough of Mansfield Water Department offer for SALE the following redundant PLANT:—

Two Lancashire Boilers, length 30ft., dia. 8ft., flat ends; grate area 21 sq. ft., working pressure 100 lb. sq. in., all valves and fittings included. Manufactured in 1919 and 1928 by Edwin Danks and Co.

Two steam-operated Boiler Feed Pumps, one by Weir, and all pipework.

One Permutit Base Exchange Unit, for softening boiler feed water, with all valves and pipework.

Further details and copies of the latest boiler reports can be obtained from the Water Engineer and Manager, Exchange Row, Mansfield, and the plant can be inspected by arrangement.

A. C. SHEPHERD,
Town Clerk.

Carr Bank,
Mansfield,
4th May, 1953. E8632

PUBLIC APPOINTMENTS

SUDAN GOVERNMENT

PUBLIC WORKS DEPARTME

MECHANICAL ENGINEER

The Public Works Department requires a M
NICAL ENGINEER for service in the
Applicants should have had experience, p
overseas, in public water and electricit
undertakings involving water purificatio
mains system, diesel power stations and
H.T. and L.T. distribution systems. They
Corporate Members of the Institution o
Mechanical or Electrical Engineers or have
lent qualifications. Candidates will be re
to the chief mechanical engineer for the
administration and control of a number
town public utility undertakings consisting
power stations with L.T. and H.T.
systems and water works covering the p
treatment and distribution of portable wate
didates will also be required to plan and s
the construction of extensions to existing
including the preparation of estimates and
for plant and equipment.

Salary: £E1700 per annum fixed rate. A
cost of living allowance is also payable w
reviewed quarterly. There is at present no
tax in the Sudan. Annual home leave on a p
scale after initial tour of approximately 18
Free passages by air both ways for officials and
Duty transport provided. Government accom
tion, as available, provided at low rent. A
allowance of £E.50 is payable on appointme

Further information and application form
sent on receipt of a postcard only, addressed
Sudan Agent in London, Sudan House, Ch
Row, London, S.W.1, quoting "M/Engineer
and name and address in block letters. E

SURREY COUNTY COUNC

COUNTY ARCHITECT'S DEPARTM

MECHANICAL ENGINEERING ASSIST GRADE V

Applications are invited for the appointm
MECHANICAL ENGINEERING ASSIST
Grade V, at a commencing salary of £595 per a
rising by annual increments of £15–£20 to a ma
of £645 per annum, plus London Allowance
to £30 per annum, according to age.

Applicants should have good technical traini
experience in the design and preparation of dra
specifications and estimates for installations o
ing, ventilating and hot water supply services i
buildings.

Preference will be given to members of the I
tion of Heating and Ventilating Engineers.

The appointment will be subject to the pro
of the Local Government Act, 1937, and the su
ful applicant will be required to pass a m
examination.

Applications, stating age, qualifications
experience, and accompanied by copies of
recent testimonials, should be sent to the C
Architect, Surrey County Council, County
Kingston upon Thames, not later than the 30th
1953.

Canvassing, either directly or indirectly,
disqualify a candidate from consideration.

The Council will be unable to provide any ho
accommodation and the successful applicant w
expected to make his own arrangements in
direction.

W. W. RUFF
Clerk of the Coun

County Hall,
Kingston upon Thames. E

HER MAJESTY'S COLONIAL SERVICE

HYDROLOGICAL SURVEY DEPARTM UGANDA

ASSISTANT ENGINEER

Applications are invited for the following po
ASSISTANT ENGINEER, Hydrological S
Department, Uganda.

Appointment on contract for 2½–3 years. S
according to age, qualifications and experien
scale £830 to £1590 p.a., plus cost-of-living allow
of 30 per cent of basic salary (maximum £300
and gratuity on satisfactory completion of contra

Candidates, who should be between 25 an
years of age, should hold a University Degr
Diploma in Civil Engineering which carries exem
from Parts I and II of the A.M.I.C.E. examina
plus two years' approved practical experience,
A.M.I.C.E. Duties include erection of river and
gauging stations, collection of hydrological
survey and design of irrigation and drainage sch

Full details available on application.

Apply in writing to the Director of Recruit
Colonial Office, Great Smith Street, London, S.
giving briefly age, qualifications and experi
Mention the reference number CDE/139/9/01. E

RAUCEBY HOSPITAL, SLEAFORD

ASSISTANT ENGINEER

Applications are invited for this post from per
who have completed practical training in Mech
Engineering and hold approved qualifications. S
scale £425 by £15 by £20 to £525. Unfurn
house available. National Health Service Su
annuation Regulations and conditions of se
apply. Applications, giving full details of qua
tions and experience, must be received by the C
Secretary, Lincoln No. 3 Hospital Manage
Committee, Harmston Hall, Lincoln, within
days of this notice. E

THE ENGINEER

MAY 15, 1953

Productivity Report on the Gas Industry

THE British Productivity Council has published this week the report of the team which visited the U.S.A. last year to study the American gas industry. The team consisted of sixteen representatives of the British gas industry and was led by Mr. J. H. Dyde, deputy chairman of the Eastern Gas Board. The report emphasises the sharp contrast between the gas industries of this country and the U.S.A., pointing out that there is no counterpart here to the rapid exploitation of natural gas resources, which, in the last decade, has transformed the economic and technical aspects of the American gas industry. Although there are no appreciable known reserves of natural gas in Great Britain, the team says that a discovery of any magnitude would be of immense value to the national economy and the suggestion is made that, where there is any possible hope of success, prospecting should continue to receive vigorous support. In a comparison of the processes of gas manufacture in the two countries, the report explains that, following the greatly developed use of natural gas, the manufacture of gas from coal, coke and oil in the American industry has declined and now contributes only about 5 per cent of the total gas sales. In this country 99·7 per cent of the total gas sold is manufactured gas. On the subject of productivity, the team states that it found no evidence that those employed in the American gas industry were working harder than their British counterparts. The view of the American industry appeared to be that where increased productivity had occurred it was due to improved techniques rather than to increased effort. Among the recommendations which the team makes is one dealing with research. The report observes that as in Britain the stocks of the best gas-making and coking coals are a diminishing asset, gas must be produced from other grades of coal or from other sources. It is suggested, therefore, that, in the matter of research especially, permanent and close liaison between the gas industries in both countries would be advantageous.

British-Built Locomotives for Export

FOUR different kinds of main line locomotives are at present under construction at the works of Vulcan Foundry, Ltd., Newton-le-Willows, and in connection with a visit from the Institution of Locomotive Engineers to the works last week, a group of engines with one of each kind was available for inspection by the visitors. These locomotives were parts of orders valued at several million pounds for overseas customers, and the group included a steam, an electric, a diesel-electric and a diesel-mechanical locomotive. The steam locomotive was one of sixty-four 2–10–0 oil-burning engines being constructed for the Iranian State Railways, and a detailed description of it appeared in our issue of January 2, 1953. The engine is of entirely new design and is one of the largest yet built at Newton-le-Willows. With a weight of just over 108 tons in working order, this engine has a tractive effort of 49,200 lb, its adhesive weight being 81·65 tons. The electric locomotive was one of sixty-three being built in conjunction with the English Electric Company, Ltd., for the Spanish National Railways. With a horse power of 3600, it is stated to be the largest electric locomotive to be built in this country. One of these locomotives, which weighs 116 tons and has a continuous tractive effort of 30,500 lb, with a maximum tractive effort of 70,000 lb, was described in our issue of May 2, 1952. The diesel-electric locomotive, also being built in conjunction with the English Electric Company, Ltd., is of 1500 h.p. and was one of ten C_0-C_0 engines being supplied to the Queensland Government Railways. These locomotives are powered with twelve-cylinder oil engines and weigh 87½ tons in full working order. They are designed for a maximum permissible speed of 45 m.p.h. and have a continuous tractive effort of 30,000 lb with a maximum tractive effort of 60,000 lb. The 0–6–0 diesel-mechanical 204 h.p. locomotive shown was built in conjunction with the Drewry Car Company, Ltd., for the Mount Lyell Mining and Railway Company of Tasmania.

The London Association of Engineers

THE London Association of Engineers was formed in 1852 to bring together foremen in the engineering industry of the Metropolis. At that time, its title was the "London Association of Foremen of the Engineering Trade," and it was stated that "friendly intercourse, intellectual enjoyment and physical good are the bases upon which its rules are founded." The Association's present title was assumed in 1931 and the scope of its membership was widened to include engineers in executive positions as well as foremen. Its activities include regular monthly meetings for the reading and discussion of technical papers and the provision of superannuation and benevolent funds. The "politics" of the engineering industry have no place in the Association's programme. On Friday evening last, a company of 250 members and guests attended the Association's 101st anniversary festival dinner, which was held at the Park Lane Hotel, London, with the president, Captain B. H. Kimberley, in the chair. The principal guest was Major-General S. W. Joslin, Director of Mechanical Engineering, War Office, who proposed the toast of "The Engineering Industry." In the course of his speech, Major-General Joslin referred to the tremendous contribution which the engineering industry had made, and was making, to the defence of this country, to its effort for the export drive and its importance to the country's prosperity, and to the useful contribution which the engineering industry continued to make to the amenities of life. He went on to stress the importance of maintaining in the engineering industry the highest possible standards of leadership, craftsmanship and technical education. Response to the toast was made by Mr. H. Sammans, M.I.Mech.E., and Mr. J. M. Storey, M.I.Mar.E. The toast of "The London Association of Engineers" was then given by Alderman B. Monk and acknowledged by the president, who appealed for support for the Association's benevolent fund. Other speakers included Mr. W. J. Haycroft, who proposed the health of "The Guests," reply being made by Mr. Parkin Sowden, of the United States Embassy, and Mr. J. E. Lines, who proposed "Kindred Associations," a toast which was acknowledged by Mr. H. C. Newell, president of the Leeds Association of Engineers.

"Birmal" Golden Jubilee

ON Tuesday, May 5th, a dinner was held at the Grand Hotel, Birmingham, with Lord Burghley in the chair, in celebration of the fiftieth anniversary of the formation of the Birmingham Aluminium Casting (1903) Company, Ltd. In association with the golden jubilee celebrations, the company has had specially written, for the occasion, an illustrated booklet, which, under the title "The Birmal Story," traces the developments over the years from 1903 to 1953 and has something to say about the early beginnings. These go back to the late 1890s, when aluminium castings were successfully produced for bicycles and motor-cars, and tribute is paid to the efforts of Lord Crawford and the Maudslay family. The years brought expansion of business and the need for larger works, together with an amalgamation with the Midland Motor Cylinder Company, Ltd., and the acquisition of Sterling Metals, Ltd. In the booklet the influence of Mr. Percy Pritchard on the development of the group known as Birmid Industries, Ltd., is outlined, and of particular interest is the production of an aluminium alloy suitable for marine purposes. This was given the name "Birmabright" and a boat yard was purchased for the construction of light alloy craft, of which the cruiser "Diana II" is mentioned as being the best known: it is stated to be still in commission after twenty-one years' service. Post-war development and reconstruction, it is stated, has been the work of Mr. E. Player, and this period has seen a great increase in the number of the company's products which now play a part in almost every industry. To-day, the company produces castings, both large and small, and by several methods, in the aluminium alloys, zinc and magnesium.

Atmospheric Pollution

ON the motion for the adjournment of the House of Commons on Friday last, a debate on the subject of air pollution was initiated by Mr. Norman Dodds. Two matters in particular were mentioned by Mr. Dodds, the first being the effect of last winter's fogs on London and other big cities, and the second the nuisance caused by dust from cement works in North West Kent. The points raised in the debate were answered by Mr. Marples, Parliamentary Secretary to the Ministry of Housing and Local Government, who said that no one would dispute the harmful results of air pollution. Progress in overcoming it, however, was no simple matter, and it was futile to think that air pollution could be abolished overnight. Mr. Marples went on to say that the Government had decided to appoint a committee, under an independent chairman, to undertake a comprehensive review of the causes and effects of air pollution, and to consider what further preventive measures were practicable. It was hoped to make an announcement shortly about the membership and precise terms of reference of that committee.

Institution of Mechanical Engineers

THE Institution of Mechanical Engineers has announced the appointment of Mr. K. H. Platt as assistant secretary. Mr. Platt was educated at Shrewsbury School and at the University of Glasgow, where he graduated with first-class honours in mechanical engineering in 1930. After practical training with Andrew Barclay, Sons and Co., Ltd., and Craig and Donald, Ltd., Mr. Platt was for some time a technical assistant in the drawing-office of James Howden and Co., Ltd. In 1937, Mr. Platt was appointed a lecturer in mechanical engineering at the School of Mines, Treforest, Glamorgan, and in the following year he went to India to become head of the mechanical engineering department at the University of Benares. He relinquished the latter appointment on the outbreak of war in 1939 to serve, first, with the Royal Army Ordnance Corps, and, subsequently, with R.E.M.E. Since the war, Mr. Platt has been concerned mainly with technical education and apprentice training, first as one of H.M. Inspectors at the Ministry of Education, and later as education officer of the English Electric Company, Ltd., at Stafford, and of the Brush Electrical Engineering Company, Ltd., at Loughborough, where he was also chief personnel officer. Early last year, Mr. Platt was appointed to represent the Institution of Mechanical Engineers on the governing body of Loughborough College, and for some months he served as honorary secretary of the East Midlands Branch until he joined the Institution's staff in London in November, 1952. More recently, he has been appointed to the governing body of the Battersea Polytechnic. Mr. Platt was elected an associate member of the Institution in 1937 and a member in the early part of this year.

The Growth of Small Water Droplets in Steam Nozzles

By DENIS J. RYLEY, M.Sc. (Eng.), A.M.I.Mech.E.*

A simple approach to the calculation of the discharge coefficients of nozzles emitting wet steam was made in an article in THE ENGINEER, *March 7 and 14, 1952. For simplicity the steam at entry to the nozzle was assumed to be wet and in thermal equilibrium, and the effluent was treated as a discrete continuous stream. Here the author extends this theory to meet the common practical condition in which the steam is dry at the entrance to the nozzle and the moisture is precipitated as droplets as the stream nears the nozzle exit.*

IN an article[1] in a former issue of THE ENGINEER, the present writer undertook a critical review of existing knowledge concerning the flow of wet steam through nozzles and advanced a new theory purporting to provide a more rigorous basis of comparison for the calculation of discharge coefficients than has hitherto existed. The theory sought to treat the movements of the droplets independently of the surrounding steam. To simplify the approach it was necessary to regard the steam at entry to the nozzle as being wet and in thermal equilibrium, and to treat the moisture in transit as a discrete continuous stream.

In very many actual cases, as is well known, the steam is dry at the nozzle entrance and the moisture is precipitated usually after a period of supersaturated or partly supersaturated expansion as the exit is approached. A study of the droplets so formed, therefore, is a necessary extension of the above inquiry. At formation these droplets are extremely minute, having an order of size falling in the range 4 to 10×10^{-9}ft diameter, and in most circumstances they will grow rapidly. Very little study has been directed towards droplet growth in steam nozzles, though the growth of droplets in air has received considerable attention, especially by those interested in cloud chamber phenomena (Wilson,[2] Hazen,[3] Barrett and Germain,[4] &c.), or in the formation of rain (Mason,[5] &c.).

It is necessary to be cautious in applying considerations based on growth in air to the steam nozzle case, as diffusion coefficients, coalescing properties and the like may differ.

The growth of large drops (*circa* 10^{-2}ft diameter) has also received considerable attention from engineers and physicists interested in surface condensation and heat transfer (Brown,[6] Hampson,[7] &c.). The principal work on minute droplet growth in steam nozzles is due to Yellot[8] and Yellot and Holland,[9] both of whom made estimates of formation and terminal size by using a glass-walled nozzle and an arc lamp and by observing the haze colour and polarisation of the scattered light.

The following paragraphs show how an approach may be made to the physics of growth and outline an analytical approach which gives results in fair agreement with observations made experimentally by Yellot.

SIZE OF FORMATION DROPLETS AND THEIR SUBSEQUENT GROWTH

It is safe to affirm that all condensation takes place in an atmosphere showing some degree of supersaturation. The latter may be very small, as in the case of condensers, or relatively large as in the present case, but equilibrium condensation, as with reversible changes generally, is only an ideal. A droplet, immediately on precipitation, thus finds itself in a supersaturated atmosphere. Kelvin and von Helmholtz[10] showed that a droplet of diameter d in equilibrium with an atmosphere of its own vapour, having a supersaturation ratio S is given by

$$R\theta\rho_W \log_h S = 4T/d \quad . \quad . \quad . \quad (1)$$

where T is the surface tension, R the characteristic gas constant, θ the uniform prevailing temperature and ρ_W the density of the liquid phase. If, however, the drop bears an electronic charge, q, equation (1) is modified and according to Tohmfer and Volmer[11] may be written

$$R\theta\rho_W \log_h S = 4T/d - \left[\frac{1}{\epsilon_1}-\frac{1}{\epsilon_2}\right]\frac{2q^2}{\pi d^4} \quad . \quad (2)$$

where ϵ_1 and ϵ_2 are, respectively, the dielectric constants of the atmosphere and of the drop. Both (1) and (2) discount any variation of T with d, an issue on which physicists appear to be still in disagreement. The quantity $\left[\frac{1}{\epsilon_1}-\frac{1}{\epsilon_2}\right]$ will not vary greatly for low pressure steam and may be taken as 0·987 for absolute pressures 0–50 lb per square inch without sensible error. Likewise, the value of R may be taken as 85·8ft-lb per lb per deg. Fah. for the range of pressures and temperatures here involved. Using these values, and taking values of T from the International Critical Tables, a plot may be made of (1) and (2) yielding a two-branched curve as shown in Fig. 1, in which the part AB results from equation (1) and the part CD from equation (2). The curve as drawn is for 15 lb per square inch absolute pressure.

For a steam nozzle in which the pressure distribution is known, S is readily calculable for totally supersaturated flow, and experimenters (Yellot,[8] Binnie and Woods,[12] Retalliata,[13] &c.) have found the formation size of a droplet knowing the pressure at the formation section and assuming the droplet was uncharged. As a pressure rise has been observed to coincide with the onset of condensation, it is a debatable point whether the initial or final pressure in this rise should be used for the calculation of S. The rise is, however, small, and S is not in practice materially affected until a large number of droplets have been formed. Visual observation of the colour of the haze formed by intense illumination gives reasonable confirmation of the calculated formation size and it may be taken that the use of equation (1) is permissible even with minute droplets.† The calculation of formation size using equation (1) presupposes that at the instant of formation the droplet is in thermal equilibrium with its surroundings and disposed neither to grow nor evaporate. In a steam nozzle, however, the characteristics of the surrounding atmosphere are changing rapidly. The temperature is fast declining, and this decline would normally lead to re-evaporation of the droplets. The reason this fails to happen is because the minute size of the droplets enables them to abrogate the normal laws of heat conduction and keep step in temperature. A detailed inquiry into the molecular physics of this problem was made by Stodola[15] and reference to his conclusions will be found to give general support to this view.

In the meantime, the supersaturation still persists, usually to a diminishing extent. It is an over-simplification, also a common mistake, to suppose that supersaturation is confined to that part of the expansion which precedes the initial and overdue onset of nucleation. It is this residual supersaturation which gives the greatest impetus to the subsequent drop growth in its middle and later stages.

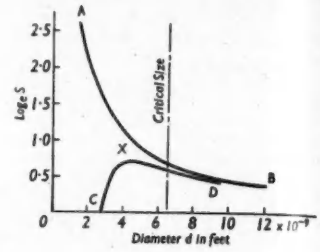

Fig. 1

Figs. 2 and 3 show the separate regions into which the total field is divided by the curves AB and CD, the upper region in either case being that of condensation; the lower that of evaporation. In disequilibrium, for a given value of θ, the prevailing values of d and S define a point which will lie above or below the line, and a droplet so situated will grow by condensation in the first case, or disappear by re-evaporation in the second. In the present case, for a given instantaneous state of the steam atmosphere, the droplet condition will always be a little above the prevailing equilibrium line, which will usually be of the type AB, and the droplet will continue to grow. This growth, in the absence of any additional agency to the contrary, will ultimately bring the droplet size to a value at which the surface curvature is too small for the operation of equation (1). By this time S will have declined in any case to a negligible residual value, and the droplet come under the influence of coalescence promoted by stream turbulence, which will encourage further growth to some terminal size (approx. 2×10^{-4}ft diameter at 15 lb per square inch for a relative steam velocity of 50ft per second), at which tearing will appear as a new limiting factor. Alternatively, deposition may take place.

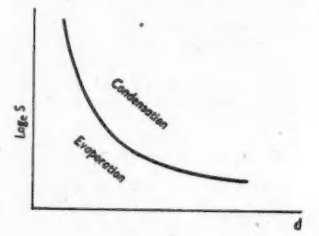

Fig. 2

It may be noticed that in the wedge-shaped space marked X in Fig. 1 a droplet will grow if charged, but evaporate if uncharged. Droplets so placed will provide a criterion of the presence or absence of a charge.

On the assumption that droplet growth is promoted by residual supersaturation, an approximate analytical approach may be made as follows.

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† It has been suggested (Rodebush,[14] &c.) that with droplets of this size order the normal physical concepts of pressure, surface tension and so on must break down. Whilst this becomes increasingly true as the size is reduced, equation (1) proves surprisingly accurate for drops containing more than about 100–150 molecules.

It has been shown that the rate of growth of a drop of mass M at a given time t is

$$\frac{dM}{dt}=2\pi Kd[\rho_D-\rho_S] \quad . \quad . \quad . \quad . \quad (3)$$

where K is the diffusivity of vapour in the atmosphere and $\rho_D-\rho_S$ the difference in vapour density between that of the atmosphere and that immediately adjacent to a drop.

Using the device recently employed by Weinberg[16] in connection with steam heat transfer to small drops, equation (1) may be written

$$R\theta\rho_W \log_h \frac{\rho_D}{\rho_S}=4T/d \quad . \quad . \quad . \quad (4)$$

which may be rearranged in the form

$$\rho_D-\rho_S=\rho_S\left[\exp.\left(\frac{4T}{dR\theta\rho_W}\right)-1\right] \quad . \quad (5)$$

By (5) in (3), by writing $M=\frac{4}{3}\pi\left(\frac{d}{2}\right)^3\rho_W$, and by simplifying, the differential equation is obtained :—

$$d\,.\,\frac{dd}{dt}=\frac{4K\rho_S}{\rho_W}\left[\exp.\left(\frac{4T}{dR\theta\rho_W}\right)-1\right] \quad . \quad (6)$$

which has the solution

$$\int\frac{d\,.\,dd}{\exp.\left(\frac{4T}{R\theta d\rho_W}\right)-1}=\frac{4K\rho_S\,.\,t}{\rho_W}+A \text{ constant.}$$

Unfortunately, the integral obtained is not amenable to solution by standard methods, nor can the integrand readily be

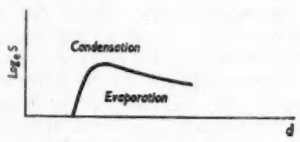


Fig. 3

expanded into a suitable series and it becomes necessary to resort to a step by step solution of equation (6).

To test the above theory, the writer chose experimental values from the work of Yellot,[8] and Fig. 4 is a part reproduction of Fig. 14 of his paper. The first traces of condensation, which he termed "preliminary condensation," occurred at point P, and droplets here formed grew until "ultimate condensation" supervened at U, some 0·75in downstream. The total time taken to traverse this length was divided into some twenty-two unequal time sections with magnitudes which were approximately in geometric progression. The time intervals were very small at the beginning of growth (the order of a few microseconds) where the growth is exceedingly rapid, and were lengthened as the growth rate declined.

The value of K was taken as equal to $k/\rho_W c_V$, where k is the thermal conductivity and c_V the specific heat of the steam atmosphere. Following Kaye and Laby,‡ the thermal conductivity was taken to be given by

$$k=1\cdot603\,.\,c_V\,.\,\eta \quad . \quad . \quad . \quad . \quad (7)$$

where the viscosity η was obtained from Sigwart's[17] expression

$$\eta=(0\cdot143t_1+56)\times10^{-7}\text{ lb/ft sec.} \quad . \quad (8)$$

where t_1 deg. Fah. is the prevailing temperature.

The use of this latter expression for partly supersaturated steam is questionable, but no other data exist. Also the value to be assigned to t_1 is obscure. Fortunately, for the relatively small range of t_1 required, the insensitivity of (8) avoids significant errors on both counts. It was found that $4K\rho_S/\rho_W$ showed a variation of some 4 per cent over the section length and could legitimately be regarded as constant. The variation of the exponent, however, was of the order of 15 per cent and had to be allowed for.

‡ *Physical and Chemical Constants*, tenth edition, page 67.

The final droplet diameter, so calculated, when ultimate condensation supervened was $1\cdot64\times10^{-6}$ft. Yellot,[8] by judging the colour of the haze, gave an average value of about $3\cdot8\times10^{-6}$ft for a numer of experiments, but he pointed out that personal errors were involved and the value must be regarded as approximate. In view of the several uncertainties incurred, it is considered that these values are in reasonably satisfactory agreement and some suggestions for the causes of difference are made below. The curves, Fig. 5, show the calculated rate of growth with time on both linear and logarithmic bases. Yellot[8] observed that the initial rate of growth was very rapid but offered no quantitative estimate, and the calculations support his observations.

Limitations of the Above Theory

It should be emphasised that the complete mechanism of droplet growth in steam nozzles is vastly more complicated than the above simplified treatment suggests. A number of legitimate criticisms may be examined : (*a*) The view has here been taken that growth is due entirely to supersaturation and that the degree of the latter is defined at any instant by the prevailing drop size. There is no reason to suppose that S and d are interlocked in the manner assumed and it is certain that S is at any instant rather greater than the above theory suggests. Such a fact is necessary to promote continuous growth and helps to explain the sudden observed onset of ultimate condensation at a point where the calculated value of S is very low. The broken curve indicates a more probable trend of S with t.

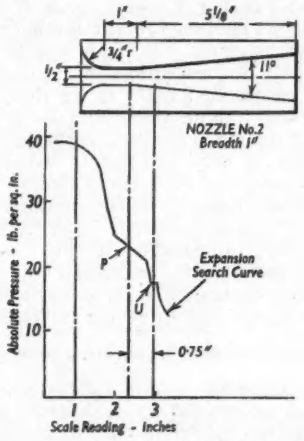
(*b*) The calculations refer to a droplet *originally* precipitated, and take no account of any additional droplets which may appear whilst the steam is in transit over the 0·75in length. It is probable, actually, that the original and now larger droplets grow at the expense of those newly precipitated.

(*c*) In the early stages, whilst the droplet is minute and still very mobile, it is subject to Brownian movement and therefore to repeated impact with its neighbours. Experiments on larger drops by Derjaguin and Prokhorov[18] showed that such drops invariably coalesced when in an atmosphere of the same vapour. It would seem, therefore, that the number of coalescences is substantially equal to the number of impacts. Any attempt to treat this statistically is greatly complicated by the fact that every coalescence produces a larger drop depending on the number of droplets involved in the collision, and this effect is further complicated by the continued concurrent growth due to supersaturation.

(*d*) Whereas the droplets at the instant of formation are moving with the same velocity as the surrounding steam, they will slow up slightly relative to the steam and thus take rather longer to traverse the section than the time calculated.

(*e*) Owing to fluid and boundary friction, which are not allowed for in the calculation, but which will be small, the expansion will not be adiabatic and the steam velocity at any section slightly reduced.

It will be noticed that in all cases (*a*) to (*e*), inclusive, a correction, were it able to be applied, would be such as to promote additional drop growth. The discrepancy between the values of final diameter as calculated and as observed may thus be taken as the cumulative effect of these factors. That the discrepancy is not larger



Part reproduction from Yellot, A.S.M.E. 1934, Vol. 56 page 420

Fig. 4

indicates that supersaturation is the main agency promoting growth. The principal contributions to the error come from (*a*) and (*c*).

No mention has yet been made concerning impacts and therefore coalescences to be expected from the normal turbulent movements of the stream. The study of the nature of turbulence in fluid streams is still in its infancy, and so far as the writer knows, no attempt has been made to treat mathematically a case such as the present one, where the impact of suspended particles is under review. It would incur the serious complications enumerated above in connection with Brownian movements. It is, however, readily shown by classical dynamics, that very small particles are highly reluctant to change their directions when in a cross wind of relatively low density, and it would seem that coalescence from this agency would not occur to any great extent in a section length as short as 0·75in.

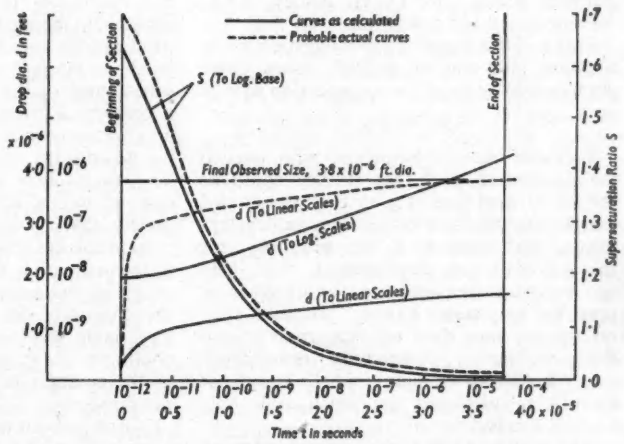

Curves as calculated
Probable actual curves
Drop dia. d in feet
Beginning of Section
End of Section
S (To Log. Base)
Final Observed Size, 3·8 x 10⁻⁶ ft. dia.
d (To Linear Scales)
d (To Log. Scales)
d (To Linear Scales)
Supersaturation Ratio S
Time t in seconds

Fig. 5—Drop Growth and Supersaturation in a Steam Nozzle

Failure of Droplets to Grow

Experiments on another nozzle, No. 1, conducted by Yellot[8] during the same

research, revealed that the very small droplets precipitated in this nozzle failed to grow. The difference in the behaviour of these droplets is accounted for by their smaller formation size, which averaged about $4{\cdot}2\times10^{-9}$ft diameter as compared with 6×10^{-9}ft diameter for nozzle No. 2. It has been pointed out by Rodebush[14] that there is a "bottleneck" size for the growth of nuclei by agglomeration, and he places it approximately at 10^{-7}cm. radius or $6{\cdot}5\times10^{-9}$ft diameter. This position is indicated on Fig. 1, and if values of S and d in Yellot's published results are plotted on a diagram such as Fig. 1, it will be found that with few exceptions the drops which grew are placed initially to the right of this line, whilst those that failed to grow are placed for the most part to the left. This provides a very satisfactory experimental confirmation of Rodebush's theory, though the plotted positions would indicate a rather smaller critical size than $6{\cdot}5\times10^{-9}$ft, namely, $5{\cdot}4\times10^{-9}$ft diameter. It also indicates, in harmony with paragraph (*c*) above, that supersaturation may be less important at the outset than Brownian movement.

Preliminary and Ultimate Condensation

The existence of two apparently different types of condensation at different sections as observed by Yellot[8] remains unexplained. The writer has attempted, using Yellot's published results, to correlate groups of relevant physical quantities, such as formation diameter, viscosity, Reynold's (or Mach) Number, supersaturation ratio, shock wave position, &c., but no significant law can be discerned. This is due to the relatively small number of published data and to their internal inconsistencies which arise mainly from the experimental difficulty of estimating the exact position of onset of preliminary condensation and of judging the haze colour. The solution of this interesting problem must await the results of further research.

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An Experimental Air-Cooled Turbine

THE INSTITUTION OF MECHANICAL ENGINEERS

No. I

AT a general meeting of the Institution of Mechanical Engineers in London on Friday, May 1st, a paper "An Experimental Single-Stage, Air-Cooled Turbine." Part I, "Design of the Turbine and Manufacture of Some Experimental Internally Cooled Nozzles and Blades," by J. Reeman, B.Sc., A.M.I.Mech.E., and R. W. A. Buswell, B.Sc.; Part II, "Research on the Performance of a Type of Internally Air-Cooled Turbine Blade," by D. G. Ainley, B.Sc., was presented for discussion.

Part I of this paper is reproduced on pages 674 and 712, and we publish below some points made by speakers in connection with it.

Discussion

Professor O. A. Saunders, who opened the discussion, said that if they could be certain of anything, it was that the cooled gas turbine was one of the coming developments, and although it was probably true to say that its development was held up more by the necessity for overcoming practical and constructional problems than on fundamental data on heat transfer and fluid mechanics, there were nevertheless many fundamental factors which could not be reliably calculated and which could only be found experimentally.

The authors were to be congratulated on building a turbine which would actually run at a high temperature—a higher temperature than heretofore—rather than in taking the easier task of building a turbine to run at normal temperatures and cooling it. Indeed, as the authors had explained, most of the fundamental data could be and had been obtained on this down-rated condition; but, unlike a great deal of the work which had been done in America, the authors had built an actually hot turbine. This was a matter for congratulation. If they had not done this, they would not have come across many of the very relevant practical problems concerned with cooling parts other than the actual blades—in particular, of course, the combustion chamber, leading-in ducts and the exit duct.

One of the most important conclusions in the paper related to the suggestion that uniformity of chordwise temperature was not necessarily the ideal which should be aimed at, because the compressive stress produced in the leading and trailing edges by this non-uniformity might in fact help to offset some of the difficult stresses and give effectively a stronger blade, or (to put it another way) all that one really needed to do was to cool the stress-bearing centre portion. This, he thought, was a very important conclusion, and, of course, it struck one immediately that it was a very important conclusion for the effusion-cooled type of blade. It seemed rather to contradict a suggestion which he had heard made that the success of the effusion-cooled blade depended on having a variable porosity in order to get more cooling at the leading and trailing edges than at the centre. It appeared that this might not be so.

If one had got as far as the authors had in using a pressed powder blade, would it not be better to go one stage further and introduce some effusion cooling, which should not be impossible?

The authors quite naturally were very guarded in their statements about the future, and they said that the limits of air cooling had not been reached. He would like to ask them whether they meant that they thought one could get a much bigger temperature difference than 270 deg. Cent. using straight internal holes. He would have thought that, with a reasonable amount of cooling air, 270 deg. Cent. was pretty near the maximum that could be obtained by this type of flow system, and this suggested to him that for a moderate amount of cooling, 200 deg. Cent. or so—which had a very great value—the choice of system would depend on the cost of manufacture. He was wondering whether there might be in the hall some who would defend some form of prefabricated blade as giving very nearly as much cooling and costing very much less to produce. He thought that was one of the points that might come out in the discussion.

Finally, he asked the authors whether they did not agree that to get substantially more cooling with air there was really only one answer, and that was to go to the effusion cooling system.

Mr. Hayne Constant, said that the decision to have a shot at the cooled gas turbine had been made as far back as 1945, when Mr. Reeman had been working with him at the Power Jets Research and Development Organisation, and Mr. Reeman had set to work to design a cooled turbine.

The first ideas on how to cool the blades—looking back on them—had been rather strange. He remembered very well discussing the use of glass fibres, tungsten sponge, covered by ceramic, and all sorts of queer things, but eventually the General Electric Company had produced the ideas that had been described in the present paper.

They had gone ahead with the project in a very systematic way. Once the turbine carcase had been delivered, they had first of all spent a year testing it without any rotoring at all, just to make certain that there were no hot spots in it, and they had spent another year testing it with uncooled blades to get over the general lubrication problems and all the problems not associated with the cooling. It was for that reason that it had taken so long.

As to the future, there was no doubt at all what they were going to do. They were going to go on putting the temperature up until they saw the first signs of trouble and then, as they wanted to use the rig to test other blades afterwards and other forms of combustion system and other liners, they would stop. They hoped they would stop just in time!

Mr. B. E. G. Forsling said that he was particularly interested in the industrial gas turbine and the gas turbine for the Mercantile Marine, and he was afraid he must express some doubts as to the suitability of this type of cooling for these applications.

In the introduction to Part I, the authors stated: "Theory shows that, apart from the simple jet engine, the gains in both efficiency and work output to be obtained by an increase of 500 deg. Fah. in the maximum operating temperature were substantial."

He wished briefly to examine that statement. Taking the basic simple cycle and assuming ideal conditions of no loss, the thermal efficiency was determined by the temperature range of the compressor, independent of the turbine inlet temperature, so that the gain by increased temperature was confined to the increase in net output. However, an actual gas turbine cycle would unavoidably be associated with losses, and therefore there would be an improvement in efficiency as well, provided the component efficiencies, particularly the turbine efficiency, could be substantially maintained, which he presumed was the basis for the authors' statement.

Taking the uncooled industrial gas turbine using the simple cycle as a basis, the turbine would be of the multi-stage design in order

to obtain a high efficiency. For a moderate pressure ratio seven to nine stages would be a suitable number in order to provide an adequate length of life of the rotor using an inlet temperature of 650 deg. Cent. (1200 deg. Fah.).

The energy available, i.e. the isentropic heat drop in the turbine, for the same pressure ratio, was proportionate to the absolute temperature. If the gas temperature was increased by 500 deg. Fah., two or three stages would have to be added in order to retain the same relative blade speed as for the uncooled turbine. This did not appear possible. In order to keep the amount of cooling air within acceptable limits, the number of stages would probably have to be reduced when the temperature was increased, so that a considerable reduction in turbine efficiency must be accepted.

Further sacrifices in performance were also involved. The net average gas mass flow through the turbine was reduced due to the diversion of the air for cooling purposes. The air used for blade cooling would, as stated by the authors, absorb some power in accelerating the air to the peripheral velocity of the blade tip. The air discharged into the gas stream at the tips of stator and rotor blades would cause some losses due to feeding the boundary layer. The effect, he suggested, was the opposite to boundary layer suction, which improved the efficiency. Feeding cooling air into the gas stream would further reduce the average gas temperature in the turbine, which was equivalent to a corresponding reduction in the inlet gas temperature. In addition, some compromise in blade shape was unavoidable. Judging from the illustrations, the authors were using straight blades, which undoubtedly was of very little consequence for a comparatively short blade length relative to the mean diameter (ratio 8·6) adopted in the experimental turbine. It was thus obvious that by using this type of air cooling a considerable reduction in turbine efficiency, as well as in the net air mass flow, was unavoidable.

The apparent necessity of using multiple combustion chambers close to the turbine appeared to be another drawback. It would be difficult to retain adequately uniform gas temperature from the combustion chambers during service conditions under speed governor control due to, for instance, uneven wear in burner nozzles. It appeared that the average turbine inlet temperature would have to be kept lower than theoretically possible in order to avoid undue high temperature at the peak from the hottest combustion chambers.

As more fuel was required for obtaining the higher initial gas temperature, he doubted whether any considerable improvement in thermal efficiency was to be expected, although the net output undoubtedly would be considerably increased. This might be illustrated by a slide, which showed the net output and the thermal efficiency at the turbine coupling of a simple uncooled gas turbine set for the assumption that the number of turbine stages was constant and the turbine efficiency was corrected in accordance with the mean relative blade speed when the pressure ratio and the inlet temperature were altered. It might be noted that, whereas the improvement in net output by increasing the temperature was considerable, the gain in thermal efficiency was surprisingly small. It was then obvous that if air from the compressor was diverted for cooling, the gain in thermal efficiency, even at still higher temperatures, might well disappear altogether.

Summing up :

(1) Unless adequately high relative blade speeds were obtained, a high turbine inlet temperature was of only moderate benefit, even when the turbine was not cooled.

(2) If air cooling was used, the performance was adversely affected unless the air quantity used for cooling was a very small percentage.

(3) Adequately high relative blade speed seemed incompatible with a sufficiently small cooling air quantity.

If a heat exchanger was added, however, the higher temperature cycle showed up better, but in view of the high exhaust gas temperature the heat exchanger would have to be made of heat-resisting materials.

Another drawback of the high-temperature, air-cooled, open-cycle gas turbine was that operation on any fuel except distillate oil and gas appeared, at present, to be out of the question.

The authors stated that with simple cloth filters comprising three layers of aircraft fabric, no measurable fouling occurred in the blade cooling passages during a period of 120 hours. For a short-life gas turbine this might be an acceptable test, but with such a large number of small cooling air passages in parallel the danger of fouling and consequent overheating was too great for industrial gas turbines.

Mr. A. G. Smith said that the turbine tests had gone some way to answering three previously quite incalculable questions. Those questions were the relation between turbine and cascade heat transfer coefficients, the strength under turbine conditions of a non-uniformly cooled blade, and what were the aerodynamic as opposed to the thermodynamic losses associated with cooling ?

Regarding the heat transfer coefficients in the turbine, they were some 40 per cent higher than expected from the cascade tests. This was a very important increase, because even with the quantities of cooling air necessary on a basis of the cascade heat transfer coefficient, the improvement in efficiency which would be got with an uncooled turbine using improved materials was something of the order of half lost by the pumping and other losses associated with the air cooling ; and if those air cooling quantities now had to be increased by some 40 per cent, then an even greater relative worsening of the performance of the cooled turbine as compared with the equal temperature uncooled turbine would result.

But he felt hopeful that there was some possibility that this particular turbine had had an unrepresentatively high ratio of turbine to cascade heat transfer coefficients. First, the turbine had untwisted blades, which must therefore result in a variation of incidence of the gas along the rotor blades ; and secondly, the design of the combustion chambers had been eased comparatively at the expense of the turbine. If the combustion chambers had delivered a rather more uniform temperature to the turbine, then the second effect which he was thinking about, which was of a variation of incidence due to the variation of velocity of the gas from the nozzle blades due to the temperature variation, would have been absent.

Regarding the strength of the non-uniformly cooled blade, the tests had shown that as far as comparatively low-stressed blades were concerned, the very high thermal stresses were not immediately disastrous. This blade had not yet been tested at stresses common in aircraft turbines and consequently further testing under more onerous conditions would be necessary to prove the type fully.

Regarding the incalculable aerodynamic losses associated with spillage of the cooling air into the main gas stream, these appeared very encouragingly low.

There was one further point regarding the estimates of the increase in turbine inlet temperature which this type of blade made possible. It appeared that the blade had been compared with an equivalent untapered uncooled blade, and if this was so, the comparison was incorrect, because the true comparison was with a highly tapered uncooled blade. If he was correct in suspecting that the comparison had been with an untapered uncooled blade, the comparison with a tapered one was likely to diminish by some 100 deg. Fah. the advantage of the untapered blade.

Mr. R. J. Welsh, said that he was interested not only in the experiment itself, but also in the end-product, and looking at it broadly he was afraid that for blade cooled turbines he could see no uses other than for aircraft in supersonic flight.

With industrial gas turbines the biggest trouble now was in trying to burn cheaper fuels, and there it might well be that, because of the ash constituents in the fuel it would not be possible to run at higher temperatures than perhaps 650 deg. or 700 deg. Cent. It remained to be seen what the final answer in regard to these fuels would be, but until that answer was found it was perhaps a little premature to think of running at a temperature of 1200 deg. Cent.

Quite apart from that, the losses associated with the air-cooled blades seemed to him to be rather heavy. The authors had mentioned that their turbine dropped 1½ per cent of output as a result of 2 per cent losses in cooling. The authors' turbine was supplied by air from external sources, and therefore 1½ per cent loss of power on it was presumably equivalent to 4½ per cent on an industrial gas turbine.

If one thought of how a high-temperature gas turbine was going to be built, there were only two ways of making use of high temperatures—either by using a high-pressure ratio or by using heat exchange. If one went to a high-pressure ratio one must have a fairly large number of stages if one wanted to get efficiency, and if each stage took 4½ per cent of the output apart from the other cooling losses mentioned, then quite a lot was going to be lost. Alternatively, if one went to a few stages, with low-pressure ratio and heat exchange, the low-pressure ratio would not give one enough temperature drop, and the exhaust temperature would be too high for any heat exchanger.

Mr. W. Hryniszak said that a multitude of small flow channels were involved, both in the development of cooled turbines and in the further development of heat exchangers such as air preheaters, and both developments were, of course, closely linked with the performance of the gas turbine as a whole. A height of 0·05in for the cooling ducts between liners and casings, and a diameter of 0·03in and 0·04in for the cooling ducts in the blades and nozzles respectively were figures that could not easily be obtained at low manufacturing costs and be maintained satisfactorily over long periods of service. On the other hand, any change in the size and shape of the cooling channels due to, say, thermal distortion or contamination of the cooling air might very severely affect the reliability of the gas turbine concerned.

He would like to inquire whether the authors had made any tests as regards the distribution of the total amount of cooling air—namely, 4 per cent—over the nozzles and blades to allow for the effect of radiation from the nozzle to the blades, especially where small reactions were involved.

He asked the authors why this particular kind of rather heavy blade had been used, instead of the more conventional hollow

blade, which was, of course, much lighter in weight and gave lower disc stresses and a lighter rotor construction. It might be easier to cool a hollow blade of this kind, and especially its trailing edge, more particularly if a thicker trailing edge could be allowed for, and he thought from a previous report on the subject that it could be. As regards the sintered blade used in the authors' tests, he inquired whether shapes other than circular ones could be successfully used for the cooling channels. If they could be, the cooling might perhaps be made more effective, especially if the blade were slotted near its trailing edge to enable cooling air to flow through the slots into the gas stream.

Price considerations were of primary importance when hollow blades were used. Even where the blades were untwisted, costs were high because of the necessity of fixing the root portion to the blade skirt, and—to an even greater extent—because of the effect of the insert. It would be interesting to know, for purposes of comparison, what was the cost of the sintered blades used in the tests.

From his own experience with sintered metallic oxides, he knew that the cost of machining sintered bars was fairly high. Did the same apply to the sintered Vitallium alloys used by the authors ?

The creep properties of the authors' alloys, (as shown in Table V), might, of course, vary from one sample to another, especially having regard to the sintering process and the importance of the size of the particles and the purity of the mixture as noted in the paper. Perhaps the authors would say whether or not the tabulated figures were average figures for a large number of samples and what the range of variation was likely to be.

The authors stressed the need of making as much use as possible of the energy of the cooling air leaving the blades. He wondered what particular method the authors had in mind.

Hanover Technical Fair

No. II—(*Continued from page 662, May 8th*)

MANY engineering exhibits of unusual interest connected with the preparation of building materials and earth-moving machinery were shown in the greatly enlarged section of open-air exhibits, which has been increased from 5000 to 50,000 square metres. In Fig. 5 we illustrate a typical corner of this section.

Esch-Werke K.G.

The firm of Esch-Werke K.G., of Duisburg, has for many years specialised in the design and construction of crushing machines for metallic ores, limestones, shales and hard igneous rocks. This year it showed in working condition the largest gyratory crusher yet built in Europe, which will be seen in the foreground of our illustration (Fig. 5).

It has a designed output of crushed material of 1000 tons per hour, and will deal with large pieces of rock having a length of up to 80in, a width up to 60in, and a thickness up to 40in. The crusher has a height of 26ft and a diameter of 16ft, and it is driven by a 225 h.p., 1500 r.p.m., motor, made by Loher and Sohne, of Ruhstorf/Rott, having "Silikon" insulation. The motor drives through a Voith hydraulic coupling to a reduction gear on the pinion shaft at 445 r.p.m. The speed of the crushing cone is 125 r.p.m. In Fig. 6 we show the arrangement of the motor drive and the oil pipe connections.

As the section reproduced in Fig. 7 clearly indicates, the top of the vertical shaft carrying the central crusher cone is supported in a spherical bearing which is completely enclosed in a dust-tight cover. Means are provided for the adjustment of the screwed nut which alters the final crushing size of the chips produced. The top of the crusher is open all round, with the exception of a cross arm, which carries the spherical bearing housing. The crusher can thus be fed from four sides. The crusher cheeks forming the outer inverted cone and the central crushing cone are made of manganese steel, incorporating from 12 to 14 per cent manganese, depending on the duty. The drawing shows that the various sections of manganese steel are built up on the central cone, and they are attached to the casing by sunken screws and bolts. The sections of the main casing are bolted together in circular rings. At the lower end of the shaft is the eccentric bearing, which produces the gyratory motion of the central cone. This bearing is completely enclosed in a dustproof casing, which also encloses the pinion and gear drive. When a plain vee-rope pulley drive is used, as on some of the smaller crushers, shearing bolts are provided. In the case of the large machine we are describing, the combined hydraulic and gear drives enable a total starting effort of some seven and a half times the normal rated load to be obtained, whereby the crusher can be started full of material. There is an electrical control panel. Failure of auxiliaries or the lubrication systems is indicated by lamps and audible alarms. Time relays form safety devices and shut down the crusher should iron enter with the rock, or any of the above-mentioned failures take place. The main motor does not start until the fluid coupling is filled, and the lubricating pumps are running and have produced the desired working pressures in the bearings. The firm also showed a similar crusher for fine chippings and a magnetic sieve.

The Esch-Werke is represented in England by Huth and Co., Ltd., of 3, Victoria Street, London, S.W.1.

Fig. 5—Open-Air Exhibits Showing Gyratory Crusher

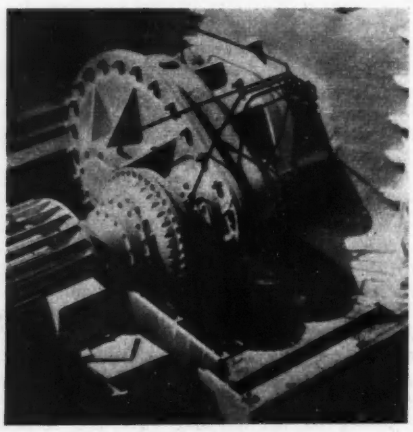


Fig. 6—Arrangement of Crusher Drive

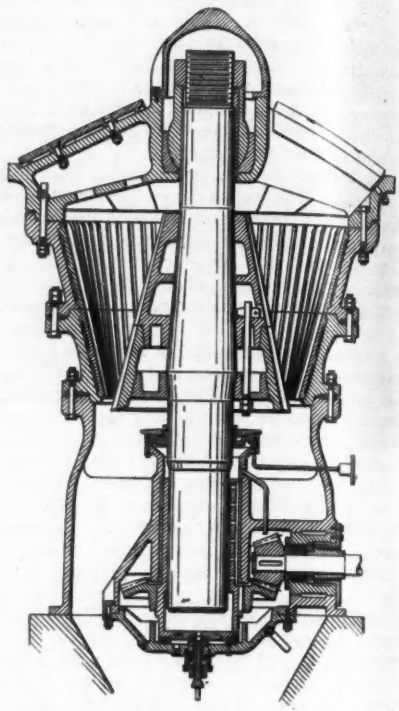


Fig. 7—Section Through Crusher

Sfindex-Meer Track Tamping Machine

Railway engineers who visited the Fair found interest in the new track tamping machine which is being built by Meer A.G., of München-Gladbach, for the Société Financiére d'Expansion Commerciale et Industrialle S.A. "Sfindex" of Sarnen, Switzerland, whose sales office is at Zurich Fraumünsterstrasse 9.

A general view of the machine is reproduced in Fig. 8. It can travel to the working site under its own power and has four speeds ahead and reverse with a maximum speed of about 28.m.p.h. The equipment has a three-point suspension, which enables sharp curves to be taken and points and crossings crossed without any danger of derailment. The driving mechanism consists of a Deutz

six-cylinder, air-cooled, diesel engine, having an output of 27 h.p. at 1500 r.p.m., and 98 h.p. at full power at 2000 r.p.m. The engine requires about 1 litre of oil for eight effective hours of work and the fuel consumption is 185 grammes per horsepower-hour. A "Rico" air compressor is driven by the engine and it has an output of 2000 litres per minute and requires also about 1 litre of oil for eight effective hours of operation. The drive is by duplex and triplex roller chains. At the forward and rear ends of the machine are two sets of rollers, one at each corner of the machine. They can be raised and lowered to contact two transverse rails, which are used to lift the machine from the main track to leave the rails free for a train to pass. The general view, Fig. 8, shows the machine in the travelling condition with the tamping tools raised. In the illustration, Fig. 9, the tools are shown in the lowered position ready to penetrate the ballast between the sleepers. The mechanism driving the tools is carried on movable frames within the fixed top frames and each of the sixteen vibrating tamping tools fitted with an inverted T-end enters the ballast bed between the sleepers and tamps it down. The tools are then brought together by the operator and the ballast is pressed under the sleeper to form a mosaic structure until the tamped level is established. The machine can also be supplied with a track measuring apparatus, which indicates the level of the rails before and after tamping. The capacity of the machine described is from 70m to 150m per hour.

Fig. 8—Track Tamping Machine—Sfindex-Meer

Fig. 9—Tamping Machine with Tools in Lowered Position

Bleichert-Transportanlagen G.m.b.H. "Westdeutschland"

The excavating machine exhibited by this firm and illustrated below is now made in Western Germany and several improvements in design have taken place. As Fig. 10 shows, it consists of a spherical headed arrangement of buckets, six in number, which have toothed edges and deliver material on to a central belt conveyor within a large diameter tube, discharging on to another belt conveyor. The headed tube is mounted on a caterpillar track with a control cabin, and means are provided to raise and lower the head by hydraulic cylinders or turn it through an arc of 350 deg. The discharge belt is also capable of being swung round through 170 deg. The conveyor belt is started before the spherical head turns, so that no crowding of material can take place. The head is provided with circular and longitudinal wearing plates, and it is driven by a geared motor through a slipping coupling on the layshaft. The motors for rotating the tube and raising and lowering both conveyors, and operating the tracks, have a total loading of 8·5kW to 9·5kW. The tracks have a width of 500mm and so do the belt conveyors. The average pressure on the ground under the tracks is about 0·7kg per square centimetre. The machine has an output of 30 to 90 cubic metres per hour, and its service weight is 9500kg. A travelling speed of about 9m per minute is provided. The machine will deal with all kinds of mass materials with maximum sizes up to 120mm, and can take material with maximum sizes up to 180mm provided that there is not more than 15 to 20 per cent of these large sizes in the total volume being handled.

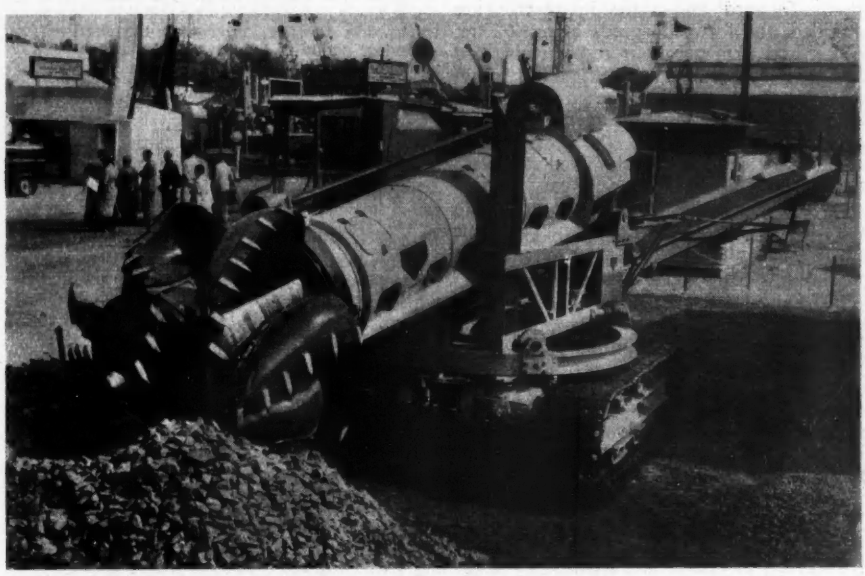


Fig. 10—Rotary Excavator—Bleichert

Fried. Krupp Essener Maschinenbau

On the Krupp stand there was a complete range of machinery and equipment for track laying and maintenance. It included a 5·5kW portable petrol-engine-driven generating set, a bolt-tightening and loosening machine, a track-tamping outfit and an electrically-driven rail-joint grinding machine, which we illustrate in Fig. 11. This machine has been designed to carry out grinding operations with any kind of rail joint, no matter whether the rail head is of full size or whether it has been worn down.

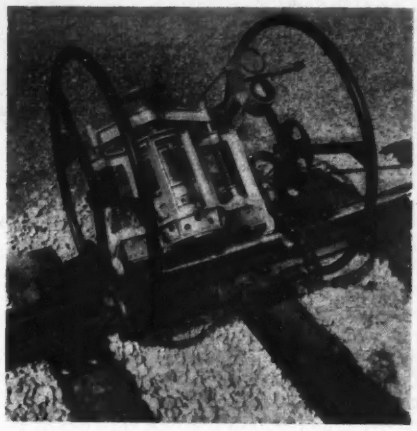


Fig. 11—Rail Joint Griding Machine—Krupp

The motor is spring mounted in the inner frame so as to move axially, and it has at the lower end a cylindrical grinding wheel. Accurate grinding around the rail head is effected by the simple operation of swivelling the inner frame to either side without changing the preset grinding wheel position. The inner frame can be swivelled 55 deg. to either side of the central position. A handwheel and handle, together with a graduated disc, is arranged at the top of the motor, and each notch gives a forward movement of the grinding wheel of 0·002in. The handle can also be locked in position. The motor has a

Fig. 12—Scraper-Dozer—Menk and Hambrock

Fig. 13—Overhead Loader and Tractor—Frisch-Hanomag

rating of 1·5kW at 220V direct current. A detachable insulated outrigger shaft is used to support the grinding machine on the other rail while it is pushed along the rail being ground. The shaft and roller carriage of the outer frame is of such a design that it can be removed readily from the track.

The Fried. Krupp Essener Maschinenbau, Essen, is represented in England by J. M. J. Maus, Ltd., of 35, New Broad Street, London, E.C.2.

Menk and Hambrock, G.m.b.H.

An improved design of scraper-dozer was demonstrated on the stand of Menk and Hambrock G.m.b.H., of Hamburg-Altona. Its general construction is shown in Fig. 12. The machine is mounted on two 500mm wide tracks with covers. It has a length of 5730mm and an overall width and height of 3300mm, the width over the tracks being 3080mm. In the centre there is a steel bowl having a total cubic capacity of 6·3 cubic metres, which can be lowered and raised by hydraulic means for digging and transporting. This bowl is closed by a knife-edged plate having a width of 1900mm. A bulldozer blade is fitted at the front. The total weight of the machine is about 19 tons. It is driven by a 150 h.p. Deutz six-cylinder diesel engine, which has a normal rating of about 120 h.p. Three speeds forward and three in reverse are provided, the forward speeds being 2·2km, 4·3km and 8km per hour respectively, and the reverse speeds 2·8km, 5·5km and 10·3km per hour. In operation the machine goes forward with the knife edge of the bowl lowered until it is full; the bowl is then raised and the closing knife-edged plate descends. The material dug can be discharged either in flat layers or dumped into holes. The pressure on the ground below the tracks is only about ¼kg per square centimetre when the bowl is empty and nearly 1kg per square centimetre when fully loaded. Menk and Hambrock are represented in England by Mr. S. Wronker, 22, Southern Road, Fortis Green, London, N.

Eisenwerk Gebr. Frisch K.G.

In the open-air section of the Fair, Eisenwerk Gebr. Frisch K.G., of Augsburg, showed one of its latest productions in earth-moving machinery, an overhead digger and loader. As will be seen from our illustration, Fig. 13, it is fitted to a "Hanomag" crawler tractor. The machine has a capacity of 1·2 cubic metres (maximum 2 tons). The width is 2200mm and the digging depth 420mm.

The machine can be used to cut earth faces of heights up to 2000mm. The greatest loading height for road or railway wagons is about 2700mm. It can be used alternatively as a bulldozer or angledozer, and there is an eight-pronged ripper, which can be used for uprooting trees and bushes. These fittings can be attached in working position in about ten minutes.

(To be continued)

Iron and Steel Institute

ANNUAL GENERAL MEETING

No. II—(*Continued from page 665, May 8th*)

THE first papers presented for discussion at the annual general meeting of the Iron and Steel Institute, in London, on Thursday, April 30th, were :—

TRAIN ARRIVALS, HANDLING COSTS, AND THE HOLDING AND STORAGE OF RAW MATERIALS

By M. D. J. Brisby and R. T. Eddison

Synopsis

The sizes of trains and incidences of arrival are examined to find out how they affect the capacity of reception sidings required to accommodate incoming wagons.

Based on costs of handling materials and stocking on the one hand, and wagon charges on the other, consideration is given to the economic balance between storing material on the ground and holding wagons under load in sidings. The greatest economy is generally obtained by aiming at holding wagons in the works for not longer than the effective free standage period of 1·5 days, depending on costs of equipment available.

A simple formula is suggested that is designed to give adequate siding capacity in relation to terminal user time and irregularity in arrivals.

RAILWAY TRAFFIC OF THE APPLEBY-FRODINGHAM STEEL WORKS

By E. R. S. Watkin

Synopsis

The works site and distribution of plant are reviewed in relation to material supplies and external communications. An analysis of the inward, outward and internal railway traffic, amounting to 268,750 net loaded tons per week, is given, with consideration of other handling methods. The layout of 100 miles of internal railway is illustrated, with reference to the principles adopted. Works rolling stock, which includes effectively 1841 wagons and fifty-five locomotives, is described, with an analysis of circulation and performance. The terminal time for inward and outward traffic is shown to be about 1·5 days, and methods of unloading surplus material are outlined, together with those for waste material. Systems used for the recording and organisation of internal traffic are described, and are related to the general needs of works production.

Mr. R. T. Eddison (British Iron and Steel Research Association), who in the absence of Mr. Brisby owing to illness presented the first paper, mentioned that as the paper had been written some time ago it contained no reference to the new 27-ton ore wagons developed in collaboration between British Railways and the transport committee of the British Iron and Steel Federation.

Discussion

Mr. W. MacLester (Stewarts and Lloyds, Ltd.): Taking Mr. Watkin's paper first, his detailed account of Appleby-Frodingham railway traffic is of the greatest interest. From one point of view we at Corby are in a similar position, in having to handle a very heavy load of ore and other materials. Corby now produces between 14,000 and 15,000 tons of iron a week, which means that over 40,000 tons of material has to be provided for the ore preparation plant and 12,000 tons of sinter has to be handled. The total number of wagons handled out of the works has increased from 392,000 in 1948 to 501,000 in 1952, due to various new sections of plant and increased production all round. Over the same period the blast furnace output has increased approximately 50 per cent and the figure for slag ladles has risen from 175,000 to 204,000 in the same period, although the ladle size has also increased. I was glad to hear Mr. Watkin refer to the importance of effective lighting in iron and steel works, where traffic is mainly controlled by visual means, and where for safety reasons and to ensure smooth working, lighting deserves a great deal of attention. The use of high flood lights has not yet been tried to any great extent at Corby and perhaps the author will give his opinion on this. At Corby we run thirty locomotives, including two diesels. I note with interest the author's rather guarded remarks on diesels. We at Corby have examined this subject in detail and from actual figures on our two existing locomo-

tives, one a 200 h.p. diesel-hydraulic and one a 400 h.p. diesel-electric, we are convinced that there are considerable monetary savings to be made as well as other advantages to be gained by the use of diesels.

Another adjunct to future traffic operation is radio-communication. This is as yet in the experimental stage in this country and results so far show that with the present development of apparatus the scope is extremely limited. The expensive equipment which has to be provided will not replace the outside foreman and the full benefit of radio-telephony for this purpose will not be obtained until we have on the market a transmitter sufficiently compact to be carried in comfort by a pedestrian. One point which the author does not mention, but which is of some importance in maintaining traffic efficiency, is the recruitment of future traffic personnel. Shunters should be young men, but unfortunately the right type is not attracted by shift work, and the wages offered are often below those paid in the production departments, so that there is a tendency for the men on whom we shall have to rely ultimately for the efficient execution of the work to fall below the desired standard.

Turning to the other paper, I find this most interesting and stimulating in its approach to the problems of siding capacity. The fact that the majority of existing works have a far from perfect layout has to be accepted as a starting-point, as numerous factors in the past, many of them insurmountable, have led to this state of affairs. Nevertheless, the theoretical principles laid down in the paper will bear close study, and they focus attention on certain traffic matters, improvements in which, whether by track modification, site alterations, or even a better form of administrative control, will result in saving time and money.

I was particularly interested in the formula given for the balance which should be maintained between stock on wheels and ground stock for a given commodity. If the wagon contents are not to be used within eight days of arrival, the wagon should be unloaded to stock. Have the authors applied this formula to any of the works which they have visited, and has such application led to any change in practice at the works in question ? The whole question is very largely governed by judgment and experience, together with a national rather than a local consideration, namely, the need to ensure quick turn-round of wagons. It seems to me that this formula cannot be applied to every commodity, due to the varied factors involved. Although at a particular works it may be economical to hold stock in wagons, the holding of the wagons from serving the rest of the industry may mean that the local saving is offset by supply shortages, with consequent production losses at works elsewhere.

Mr. A. J. Harby (Steel Company of Wales, Ltd.) : I have three comments to make on Mr. Watkin's paper. First, he does not mention the problem of where road haulage and rail can meet in the iron and steel works. We are finding that they can be complementary, and that the lorry is proving itself to be an economical and also a time-saving method of moving the smaller, urgently-required loads, particularly the engineering requirements, and also of handling the disposal of slag, due to the flexibility which results from its use. There is also the increasing tendency to despatch by road steel products, and particularly sheet, due to customers having in some cases a definite preference for that method. A point that arises especially where there is a tendency to turn over from rail to road is the disadvantage of the combined road-rail dock for loading.

My next point concerns wireless. My company has been using wireless for about two years, and we find that for specific traffics, and particularly where ingots are being delivered from two or more melting shops to a common stripper bay, it is invaluable. This traffic is controlled by one man on the shift, who is chairborne—he is very nearly airborne as well, as he is at the top of the building—and who does not get on the ground, but he is in complete telephonic communication throughout the shift with the melting shops, the mould bay and the steel planner in the soaking pits, and he can direct his locomotives to deal with the varying requirements which arise in an open-hearth process.

Lastly, on the question of locomotives. We are at the moment running a fleet of steam locomotives and also a fleet of diesels, and we are beginning to be able to make a comparison between them. It is too early yet to be definite ; it is probably fair to say that you need seven or eight years before you get a true cost of maintenance. However, in the two and a half years for which we have had the diesels working we are beginning to get a fair indication. I exclude manning charges, because they vary in different works ; in some works there are three men and in others two. Excluding manning from the running costs, we find that the advantage of the diesel as compared with the steam locomotive is of the order of 10s. per locomotive hour.

Mr. M. G. Bennett (Operational Research Division, British Railways) : I am glad that Messrs. Brisby and Eddison have not fallen into an error which they might easily have fallen into when they examined the frequency of arrival of trains of scrap and coal and so on. A superficial examination of the position might lead one to imagine that there was no planning whatever behind railway operations. Of course, with an undertaking so complex as a railway there must always be so many random influences operating that whatever statistics are taken there is bound to be some fluctuation in a random fashion. It will be obvious to you that there are a number of factors on railways over which we have very little control, such as the putting on rail of the traffics which have to be carried. We very often get co-operation from our traders, but that is not a matter over which we have any absolute control. Then there are trains, mainly passenger trains, which have to be run at certain times of the day, and other trains have to be fitted in as well as possible in between. The net effect looks rather like the curve which would result from a completely random despatch of trains, but that does not mean that things are not planned so far as it is possible to do so.

In the matter of storage, the turnround of wagons, and so on, however, it would appear from this paper that it is in the interests of British Railways and of the iron and steel industry to do what is economical, and to reduce standage even below the figure at which free standage is obtained. I wondered whether the mystic value of 1½ days was merely an arbitrary figure for free standage, but the conclusion of the paper is that by and large it would pay to reduce it to an even smaller figure than that, and also that if material is to stand in store for a long time as a buffer it should be unloaded rather than stored in wagons.

I have not been able to study the paper on railway traffic at Appleby-Frodingham, but I wondered whether some of the apparently conflicting evidence which exists on the question of steam versus diesel locomotives may not be explicable by the different loads to which they are put. The characteristic curves of steam and diesel locomotives, comparing fuel consumption with load, differ, and it may be found that some of the inconsistencies are ironed out if you look at the problem from the point of view of the load.

Mr. M. F. Barnard (British Iron and Steel Federation) : Although one would not expect sidings to have been altered very much over the last seven or eight years, I find that iron ore over British Railways has gone up from 6½ million tons in 1947 to 10½ million tons in 1952. On what plan has that been dealt with ? Has it been by the wagons being kept under load or by the handling of traffic into store ? In any case the results achieved have been excellent, and I think that the steel works should be congratulated. We must bear in mind that the standage scheme came about in an unusual way. The railways were attempting to get much higher demurrage charges and they had not appreciated the fact that there were, in effect, private railways in all the works which were often much larger than some of the smaller ungrouped railways of pre-war days.

I should like to refer to a few points to show how progress is being made. Mr. Eddison said that he and Mr. Brisby had not been able to take into account the 27-ton wagon. The 27-ton wagon has come to stay and about 3000 of them are in operation. The larger hopper wagon has also come to stay, and there are only about 14 per cent of the hoppers on British Railways which have not a carrying capacity of at least 20 tons. I think it can be said that the average loading of iron ore, over 90 per cent of the loads, is in the neighbourhood of 20 tons for hoppers and 25 tons for the 27-ton wagons. That can be taken into account in establishing the relationship between the holding and reception sidings and what you put into stock. There are two other points which should be borne in mind. I understand that there is to be a change in the loading of trains of 27-ton wagons. At the moment, with fifty 13-ton wagons, the load would be 650 tons, but with the 27-ton wagons there has been a limit of 378 tons. That is now to be lifted to 675 tons. These points help you to reassess the value to be derived from these papers.

Mr. C. Hulme (Steel Company of Wales, Ltd.) : My comments will be confined to Mr. Watkin's paper. With regard to the works wagon fleet, a large steel company in the North of England has developed a 45-ton hopper wagon running on two axles. This strikes me as being the largest load which it is physically safe to deal with in this manner. The latest wagon at Appleby-Frodingham, in comparison with this, carries 30 tons, and the average for other steel works is very much less. I am referring only to wagons on two axles. Does the author consider that this 45-ton wagon is likely to be a successful venture, and has he any thought of adopting it in his own works ? With regard to double track running, the author is correct in stating that double tracks do not offer the advantage of separate up and down running except in very specialised cases, but it is a very considerable advantage that, where there is congestion, through trains can pass trains which are shunting, and that many more trains can be handled without difficulty in any particular area. At the Steel Company of Wales, at the moment we have left and right-hand running

only on one set of double tracks, and with some alterations in the near future that will be applied over one other section of the works. I do not think it was ever the intention that it should be a general rule, although the layout of the works makes it look on paper as though double-track running was the intention. Actually we have a series of long loops which are joined together.

The figures given in the paper for derailments seem to be rather high, and for comparison I give figures for the Steel Company of Wales. For the whole of 1952 they averaged 3·3 per week, made up as follows : defective rolling stock, 0·3 ; defective track, 0·5 ; operators' errors, 2·0 ; and unknown, 0·5. That is a different form of analysis from that used by the author, but is the only basis on which ours is made. It is interesting to note that when the new Abbey Works came into commission the derailments for the first few months were at an alarmingly high level, but they quickly came back to the average of the older works as the operators became accustomed to their jobs. Lighting by towers has come in for adverse comment, but this form of lighting is undoubtedly satisfactory in districts where fog and mist are conspicuous by their absence.

With regard to the tipping of slag ladles, I note that opinion at Appleby-Frodingham has been against power tipping, which was performed there by steam. At Margam a similar kind of ladle is tipped by compressed air, the compressors being permanently sited on the slag bank, and this method has proved very satisfactory. There are three possible modifications of this method. The first is tipping by air compressor on a diesel locomotive—that is, the compressor used for the brake gear. The second is tipping by a compressor carried on a car in front of the locomotive and travelling with each train, and the third is tipping by mobile compressor on the slag bank itself. We have used the third method only as an emergency method in the case of breakdown of the normal equipment. I believe that opinion is becoming adverse to the steam tipping of ladles owing to heavy maintenance, probably due to condensation of steam in the pipes, cylinders and valves. On the subject of materials disposal and putting into stock, so far as stocks which are not held in the various production departments are concerned, these are held, and the stockyard operated, in a very similar manner to that used at Appleby-Frodingham. Until the construction of the new coke ovens was completed coking coal was never held in ground stocks ; reserves for the ovens then in operation were held in wagons to cover holiday periods. Coke oven coal is held in six grades, but not in age groups, as it is the practice to clear up the stock at each holiday time and start fresh stocks immediately afterwards. With regard to alternative handling methods and future methods, we are at present considering a new stock ground, particularly for coal, to hold 100,000 tons of coking coal in two age groups, with six varieties in each group. We would have a travelling tippler surmounted by a small travelling grab crane, which would place the coal a sufficient distance from the tippler for bulldozers to push it forward into stock. With a stock ground 200ft wide, three "D8" bulldozers would be required under the busiest conditions. The travelling tippler would be of a type similar to that shown in the paper. So far as ash and rubbish disposal is concerned, this same type of tippler has been considered by us for dealing with rubbish ; but the use of a machine capable of tipping 1000 tons per shift for a present-day ash and rubbish disposal of 1500 tons per week is not economical, and the existing system of using a machine with a pusher plate to empty 80 per cent of the wagon contents is to be continued.

On the question of traffic operation generally, it seems to me that the iron and steel works of the future will use rail track and locomotives for handling the bulk production materials, but that road transport will be used more and more for handling maintenance material, for dealing with the smaller individual quantities of these miscellaneous materials. Some people have the idea that a railway wagon is a storage space, and the sooner we can get rid of that attitude of mind the better. In the production line things move fairly fast, but if we get congestion in the works and analyse the cause it is usually due to an accumulation of odd individual wagons, all supposed to be going to different destinations.

The authors then replied to various points raised in the discussion.

When the meeting was resumed on Thursday afternoon, April 30th, the first paper presented was :—

DEVELOPMENTS IN THE ROLLING OF BROAD FLANGE BEAMS AT THE CARGO FLEET IRON COMPANY, LTD.

By G. Barry Thomas

Synopsis

The initial trials by which broad flange beams have become a standard product in a conventional two-high cross-country mill are described. Details of roll design, the method of working both in the cogging mill and in the finishing mill, and the construction of the vertical roll housings to produce a beam with parallel flanges are given.

Discussion

Mr. B. Chetwynd Talbot (Cargo Fleet Iron Company, Ltd.) : I do not pretend that I have played any part at all in the practical development of the rolling of broad flange beams at Cargo Fleet. We looked on it in the spirit of pioneering a new product in this country, and we realised that by developing the broad flange beam we were giving to this country advantages which had hitherto been available only in the U.S.A. in particular and on the Continent. We quite accept the fact that our present method is not perfect and can be improved, and no doubt in the course of time it will be ; but, as we had the facilities available for the immediate production of the broad flange beam section, we tackled it in that manner.

Mr. R. Mather (Skinningrove Iron Company, Ltd.) : Like Mr. Talbot, I do not claim to be able to discuss the more technical aspects of this valuable paper, but I feel that it would be a pity if I did not take the opportunity, on behalf of the many members of the heavy steel industry, of welcoming the appearance of a paper of very direct interest to the operating men in that important section of the industry.

Mr. J. McLaughlan (Appleby-Frodingham Steel Company) : I am quite unable to enter into a discussion of the technicalities of rolling broad flange beams. I have been associated with the Appleby-Frodingham Company for some twenty-five years, and, as is well known, the rolling of the ordinary British Standard section is carried out there in, I hope, a reasonably good manner. In view of the fact that I have had that experience of ordinary beam rolling, I shall not be misunderstood when I endeavour to impress you by saying that this is a very fine achievement indeed in producing joists, or beams for that matter, with a 12in flange in a mill of the conventional two-high type.

I have a few questions, some of which are comparatively simple. On page 113 it is stated that the bloom was 15½in by 7⅛in by 15ft long. I gather that this is a slab, but I do not gather what the difficulties were in shearing on the flat. All our blooms are sheared on the flat. Secondly, was the roll neck diameter increased from 18½in when the centres were increased ? The author speaks of a yield of 90 per cent from bloom to finish. What is it from ingot to finish, as an easier guide ? Is there a very long crop end ? Is the saleable part of the section up to its full width of 12in, or do they risk a little bit ? When I first saw these designs my first thought was " I do not know anything about rolling beams, but to work on the close flanges with very little taper is to take a big risk." Is any lubrication used, or is reliance placed on the ordinary method of stripper guards ? Has the use of roller straightening machines been considered ? Does the author know whether these broad flange beams are straightened on roller straightening machines elsewhere ? I appreciate the difficulties and I think that vertical side rods would be necessary along with the horizontal. It is apparently the intention to produce 30in by 12in, and that is really courageous. With the addition of only another stand is it proposed to enlarge the barrel length, and, if not, is one stand enough ? Is it still hoped to get two passes in each of the roll positions ? Twice 30in is 60in, which leaves about 12½in for three collars, or about 4in to each collar. I have one question with regard to competition from the Grey mill which is going in, I understand, in the author's district. I should like to ask the author whether his quality of finish will enable him to compete with the orthodox type of mill for this section. Finally, has he ever given consideration to rolling the smaller sizes—say, up to 10in by 10in—in the conventional type of two-high mill without the use of any external device, such as a vertical roller ?

Mr. E. L. Burgess (Appleby-Frodingham Steel Company) : In the layout shown for 12in by 12in beams in Fig. 3 in the paper, the last pass in the third stand, No. 12, is shown as 12½in wide, with the finishing pass set at $12^{7}/_{32}$in. Assuming that these sizes are for new rolls, and that this will give approximately 12⅛in, it would be interesting to know what happens when the rolls reach the end of their lives and the No. 12 pass becomes, say, 12⅜in, and the finishing pass approximately 12in. Will these conditions tend to produce buckled webs ? Again, the webs may buckle with the wider beams by the contraction of the flanges on the cooling bank. Does this happen, and can anything be done to counteract it ?

My second point concerns the layout of the design for the 24in beams. Would not manipulation time be saved by working straightforward in the second and third positions and running the bar back between the stands ? In the 12in design three passes are run with open flange to open flange and closed flange to closed flange, and I do not doubt that two passes of 24in would go the same way. It would be interesting to know whether this method was tried originally and abandoned for some reason. The question of wing or double collars would not arise in these circumstances. The author stated that usually each motor drives two pairs of rolls, and apparently this is the case with the 24in beams. Would not the output be improved if the roughing end motor drove only No. 1 stand, which has nine passes, and the finishing end motor drove the other stands, which are only five passes ? This would provide a more balanced arrangement, and I assume that the slack pass could be taken between Nos. 1 and 2 stands.

(*To be continued*)

North Sea Liner "Leda"

The Bergen Line recently took delivery of the passenger steamship "Leda" for the company's service between Bergen and the River Tyne. The ship, which has a gross tonnage of 6670, has accommodation for 503 passengers, and is propelled at a service speed of 21 knots by twin screws. Power is provided by two sets of double-reduction geared turbines developing 13,000 s.h.p. and taking superheated steam at 450 lb per square inch pressure and 800 deg. Fah.

ON September 3rd of last year, Her Royal Highness Princess Astrid of Norway gave the name of "Leda" to the twin-screw passenger liner which Swan, Hunter and Wigham Richardson, Ltd., was constructing for Det Bergenske Dampskibsselskab. of Bergen. Seven months after being launched the ship carried out her sea trials and after their successful conclusion the liner was handed over, on Tuesday, April 7th, to her owners. A luncheon was held on board shortly before the ship sailed for Norway, and was attended by representatives of shipping interests.

The new ship has been specially designed for the fast passenger and cargo Bergen/Tyne service, of the Bergen Steamship Company, Ltd., which serves as a link between the United Kingdom and West Norway. Following a shake-down cruise, during the course of which the ship visited London and various ports in Norway, the ship returned to the Tyne to sail on her maiden voyage in the company's service early in May, and would, by reason of her speed, be able to make two round trips each week, one via Stavanger and the other direct to Bergen, the time for crossing being respectively seventeen and nineteen hours.

The ship replaces a previous ship of the same name which was built by Sir W. G. Armstrong Whitworth and Co., Ltd., and engined by Wallsend Slipway and Engineering Company, Ltd., in 1920, and was sunk during the war off Stettin. She was the first turbine-driven ship to operate on the route and carried ninety-eight first-class and forty-seven third-class passengers at a service speed of 15 knots.

From the accompanying photograph it will be seen that the ship has an impressive profile dominated by a large streamlined funnel painted black with the well-known three narrow white bands of the Bergen Line. The black painted hull has a raked contour plate stem and cruiser stern, with a white painted superstructure having a radiused front. There are two masts. Two sets of double-reduction turbine machinery constructed by the Wallsend Slipway and Engineering Company, Ltd., supply the necessary power to twin screws to give the ship a service speed of 21 knots.

Design and Construction

The ship has been built under the survey of Det Norske Veritas, to obtain +1A.1, the highest classification of that society, and also conforms with the rules of the Norwegian Board of Sea Control, and, in addition, meets the requirements of the International Convention of 1949. Welding has been largely used throughout the construction of the ship for joining purposes, except for the frames and beams, which are riveted. Within the main hull there are two continuous decks, main and upper, while the lower promenade deck also extends for the full length of the ship. In way of No. 1 and No. 2 holds there is a lower deck to form a cargo 'tween deck space and aft of the engine-room another section of the lower deck forms No. 3 hold, and provides a flat for additional tourist class cabins. The superstructures consist of the upper promenade deck, a boat deck, on which is a long deckhouse constructed of aluminium alloy, and a raised navigating bridge. Subdivision of the ship is effected by eight main transverse watertight bulkheads, which extend to the upper deck, and further subdivision is provided by bulkheads forming the two fresh water tanks forward, the fresh water and distilled water tanks in the tunnel space, and the oil fuel cross bunker immediately forward of the stabiliser compartment. The main bulkheads are fitted, as required, with watertight doors, supplied by J. Stone and Co. (Charlton), Ltd., controlled by the company's hydro-pneumatic power-operated system from the bridge. All twelve doors are of horizontal sliding pattern and of composite construction. Should the power supply to the main hydraulic pump fail the pressure reserve in the accumulators is sufficient to operate all doors three times, and as a further safeguard a manual hydraulic hand gear has been supplied. Each door may be worked locally by hand and the system is arranged so that when all doors are closed from the bridge it is possible to open any door locally by power, and when the local control is released the door automatically closes again.

The fore peak is arranged to carry water ballast and water ballast is also carried in the double-bottom tanks in way of No. 1 and No. 2 holds, the boiler-room and the engine-room. Fresh water is carried in the double-bottom at No. 3 hold, while other tanks under the engine-room and the oil fuel cross bunker are reserved for oil fuel.

Dimensions and Particulars

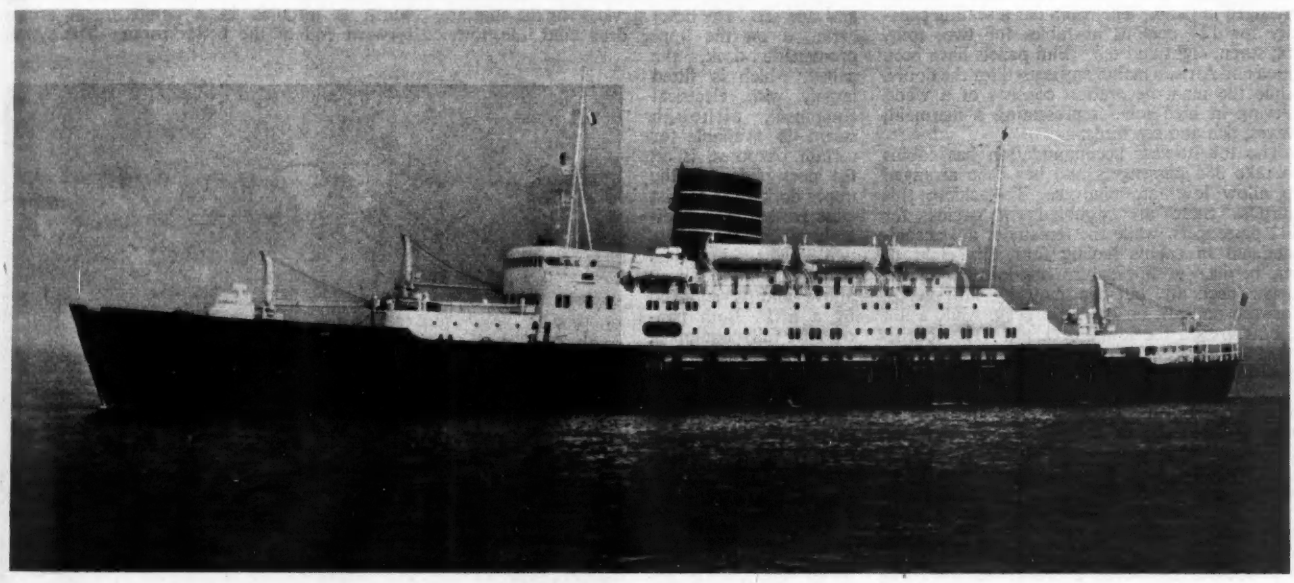
Length between perpendiculars	410ft
Breadth moulded	57ft
Depth moulded to upper deck	30ft
Draught	20ft
Deadweight (on above draught)	1970 tons
Cargo capacity	75,630 cubic feet
Gross tonnage	6670
Service speed	21 knots
Accommodation :	
First-class passengers	119
Tourist-class passengers	384

Machinery :
Type : Twin-screw, double reduction geared turbines, service power 13,000 s.h.p. at 150 propeller revolutions
Steam supply : Two Babcock and Wilcox boilers, steam pressure 450 lb. per square inch, superheat 800 deg. Fah.
Type of generators : Three 350kW Brotherhood turbine-driven generators
Emergency : One 80kW diesel-driven generator

Both the masts are of butt welded tubular construction and were fabricated in aluminium alloy by Norsk Flyindustri. Aluminium alloy has also been employed in the construction of the funnel, the shape of which was tested by Thermotank, Ltd., to ensure its efficiency with regard to the smoke clearing the decks. The hull form of the ship was decided upon after models had been tank tested by the National Physical Laboratory at Teddington.

Accommodation

The 119 first-class passengers are accommodated in single and two-berth cabins located on the upper and lower promenade decks and the upper deck. There are some de luxe cabins and many others have a private toilet adjoining, while the remainder are fitted with running hot and cold water. The first-class entrance hall, in which is a portrait of H.R.H. Princess Astrid, is situated forward on the upper deck and a stairway leads up to another hall on the lower promenade deck and then continues up to a hall on the upper promenade deck. Double swing doors to port and starboard open forward to the observation lounge, panelled in Cuban mahogany, which we illustrate. It extends for the full width of the ship and is divided into one centre and two wing sections by panelled and glazed bulkheads, provided with galvanised troughs to take floral decorations. The room is furnished with an informal arrangement of tables, chairs and settees upholstered in patterned and striped coloured material. From the lounge an arched opening to port



The Steamship "Leda"

First-Class Lounge

First-Class Dining Saloon

leads aft to the bar, while a door to starboard opens on to a small and comfortably furnished writing room. For the bar the panelling is in fumed oak while for the writing room pear-tree has been used. At the aft end of this deck is a promenade space, which is partly covered and is served by a small deck bar, and ladders lead up to additional promenade space on the boat deck. Passageways to port and starboard lead aft from the hall on the lower promenade deck to the dining room, seen in our photograph, which is "L"-shaped extending the full width of the ship and is fitted with large windows arranged in pairs. The room has a seating capacity for 124 persons at tables for two, four, six, seven, eight and ten. Elm panels have been fitted and African mahogany is used for the doors, while the main decoration consists of a wood carving in high relief representing a mermaid, waves, fish and sea birds.

The tourist-class accommodation has cabins to take 384 passengers and has been arranged to allow low fare charges. To achieve this purpose there are double-berth cabins for 142 passengers, while the remainder are accommodated in cabins having four, six, eight or ten berths. A few cabins are located on the upper deck aft, but the majority are placed, forward and aft, on the main deck, while a few cabins are on the lower deck aft. The tourist-class entrance hall is on the upper deck forward and a stairway gives access to the cabins on the main deck, from which a stairway aft leads up to another hall on the upper deck and then up to a lobby at the aft end of the deck house on the lower promenade deck. From the lobby, doors open on to an open promenade deck space, which extends to the ship's stern, while other doors to port and starboard give access to the lounge. This is a large and comfortably furnished room panelled in elm, and divided into alcoves by means of partitions consisting of panelling and grilles. There is a bar placed forward to port and a central space is fitted out as a writing room. The general appearance of this room can be seen in the photograph which we reproduce. The restaurant, which has panels of Oregon pine, is on the upper deck and, as an economy measure, is arranged to operate on the cafeteria system and has a seating capacity of 154 at tables for four or six. There is a shop for the use of both first and tourist-class passengers adjacent to the entrance halls on the upper deck. The architects of the shipping company have been responsible for the design of the public rooms and the decorations are the work of Norwegian artists.

The seamen and stewards are berthed mainly in double cabins, which are situated forward on the main and upper decks, while the accommodation for the engine-room ratings is on the main deck to port abreast the engine-room casing. On the boat deck are the cabins for the officers and engineers, including suites for the captain and chief engineer. Separate messes for the officers, crew and stewards are arranged on the upper deck to starboard abreast the galley.

The ventilation arrangements for the whole of the accommodation for passengers and crew have been the responsibility of Thermotank, Ltd., and the "Thermoreg" system of mechanical ventilation and heating is installed throughout. All fresh air entering the system passes through oil-immersed air filters.

Ship's Services and Equipment

For the rapid handling of baggage to the cabin decks two baggage lifts are installed, one forward and one aft. The hotel services for the ship are arranged on the upper deck and the lower promenade deck, the galley, which is fitted largely with electrical equipment, although steam is available for certain purposes, is on the port side of the upper deck. The tourist class pantry is immediately aft of the galley, while the first-class pantry is on the deck above and is supplied by a lift. Both pantries are fully equipped, including dish and glass washers and cold cabinets, while the galley has an island range of electric ovens, a dough mixer, and steam-jacketed boilers, &c. Below the galley are the provision rooms and cold stores, which are served by lift from the upper deck, while another lift links the provision rooms directly with the first-class bar on the upper promenade deck. A fourth lift connects the upper deck with the engineers' accommodation on the boat deck. All the lifts have been supplied by Pickerings, Ltd.

Tourist-Class Waiting Room and Lounge

There are three hatchways, each fitted with MacGregor sliding steel hatch covers, which are trunked to No. 1 and No. 2 'tween decks and holds and No. 3 hold. All the cargo spaces are insulated with fibre glass lined with aluminium alloy, and at No. 2 'tween decks two insulated lockers have been provided for the carriage of frozen fish. The refrigeration machinery for the holds has been manufactured by Drammens Jernstoberi, of Norway, while L. Sterne and Co., Ltd., has supplied the machinery for the fish lockers, provision rooms and cold cabinets. On the lower promenade deck in way of No. 2 hatch the superstructure is extended to form an enclosed space which has large double-entrance doors to port and starboard and which is allocated for the carriage of motor-cars. Three 3-ton electric cranes provided by T. B. Thrige, Ltd., of Denmark, serve the hatchways, and the same firm has supplied the after capstan, while for handling the chain cable an Emerson Walker electric windlass is installed. John Hastie and Co., Ltd., has manufactured the four ram electrically powered steering gear which operates the semi-balanced rudder.

For the increased comfort of the passengers, by the reduction of the angle of roll, the ship is equipped with the Denny-Brown ship stabiliser, which is installed in a compartment at the forward end of the boiler room. The system consists primarily of two activated fins, of streamline sections, set transversely, one on each side of the ship, and arranged to project at an angle from the horizontal from the hull at the turn of bilge. Each fin tilts about its athwartships axis so that it is angled relative to the streamline flow, and both fins are operated synchronously but in opposite directions. With both fins extended and angled, and the ship moving ahead, the velocity of the water causes an upward force to be exerted on one fin and a downward force on the other, so forming a couple which provides a righting moment which varies with the area of the fins, the angle of rotation and the speed of the ship. On the "Leda" each fin has an area of 31½ square feet and gives a maximum lift of 26 tons at 21½ knots when angled to 20 deg. to provide a righting moment of 1500 tons-feet. With the stabiliser in operation the fins are

automatically controlled by two gyroscopes, the movements of which are transformed to operate hydraulic machinery which can effect a complete reversal of fin angle in 1¼ seconds. The power units installed include two V.S.G. tilting pumps and one tilting motor developing 37·5 b.h.p. at 600 r.p.m., one V.S.G. servo pump and one 10 b.h.p. servo motor. A switch box on the bridge controls all the stabiliser gear and, when not required and to facilitate docking, the fins can be retracted within the hull and housed in specially constructed fin boxes.

The fire-extinguishing arrangements comply with the regulations of the International Convention and the passenger spaces are divided into zones by fireproof bulkheads A "Grinnell" automatic sprinkler and fire alarm system has been supplied by Mather and Platt, Ltd. The pressure tank for the system is housed in a flat to port in the stabiliser compartment and the sprinkler fire pump is located in the boiler-room. Walter Kidde Company, Ltd., has been responsible for the "Rich" smoke detection system installed in the cargo spaces, together with the steam fire-extinguishing arrangements, and this company's system of CO_2 fire-extinguishing is fitted in the boiler-room. The CO_2 bottles for the system are stowed on a flat to starboard in the stabiliser compartment.

The life-saving equipment includes six 9·65m lifeboats, each having a capacity for ninety-nine persons; five of them are equipped with Fleming hand-propelling gear and one with a 16/24 h.p. motor. There are two 6·70m rowing lifeboats each to carry twenty-eight persons, and the necessary buoyant apparatus. All the boats are carried overhead in Welin MacLachlan gravity davits, and all are built of aluminium alloy and supplied by Aluminiumsbaater A/S, Norway.

The instruments essential for safe navigation of the ship fitted include Marconi radio, two radar sets, one of 10cm and the other of 3cm, and a Decca navigator.

Propelling Machinery

In the accompanying line drawing can be seen the general arrangement of the engine and boiler-rooms and the generator compartment. The propelling machinery, constructed by the Wallsend Slipway and Engineering Company, Ltd., consists of two sets of steam turbines taking steam at a pressure of 450 lb per square inch and a total temperature of 800 deg. Fah. and designed to develop an ahead power in service of 13,000 s.h.p. at propeller revolutions of 150 r.p.m. Each set of engines consists of h.p. and l.p. turbines, the h.p. turbine being of impulse design, while the l.p. turbine is fitted with impulse-reaction blading. The astern turbines are designed to develop 70 per cent of the ahead power and each consists of three two-bucket impulse wheels incorporated in the l.p. turbine casing. When developing the normal service power the h.p. turbines are running at 6000 r.p.m. and the l.p. turbines at 3500 r.p.m., and all are connected by flexible-claw couplings to the primary pinions. These are of nickel steel, while each primary gearwheel consists of a cast steel centre with shrunk-on forged steel rims and is fastened to a forged steel gearwheel shaft. Each main wheel, of the double helical pattern gearing, has a cast iron centre with a shrunk-on forged steel rim and is securely fastened to the forged steel gearwheel shaft. This main wheel is driven by two main pinions driven respectively by the h.p. and l.p. turbines working in series through double-reduction articulated gearing to each propeller shaft.

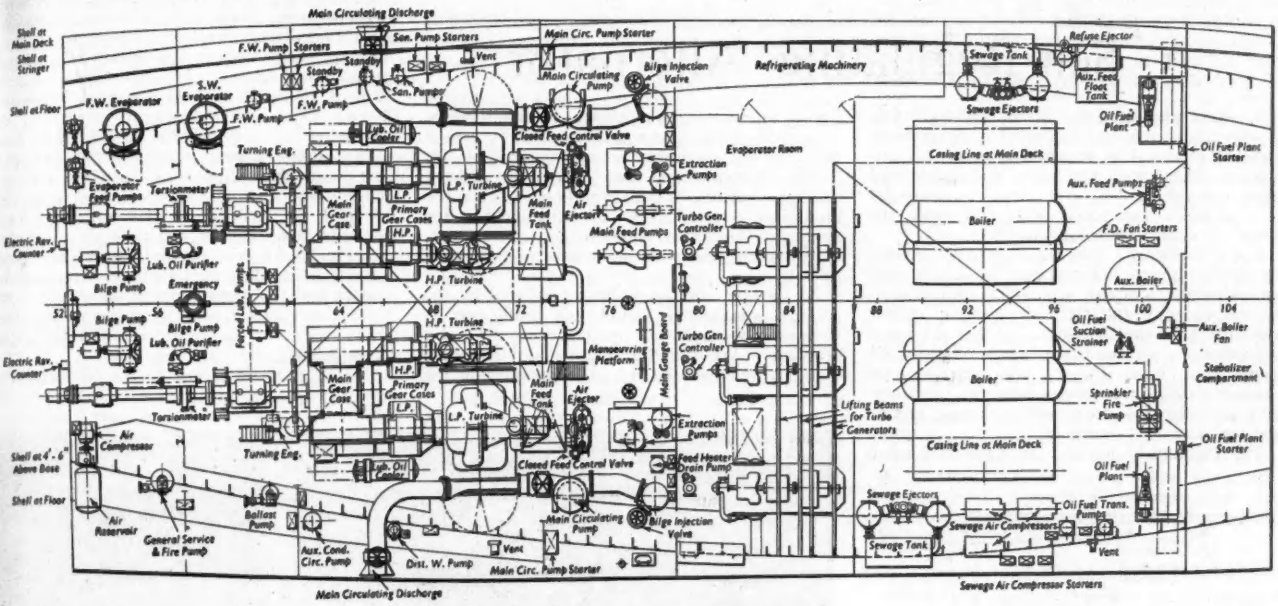
Forced lubrication has been adopted for all turbine and gearing bearings and also the main thrust blocks, which are of Michell pattern.

The four-bladed, solid propellers, which are designed to absorb the service power at 150 r.p.m., have a diameter of 14ft 6in, weigh 7¾ tons each and are of "Scimitar" design. They were supplied by the Manganese Bronze and Brass Company, Ltd., and are cast in the nickel aluminium bronze alloy named "Nikalium," which the company has recently introduced and which it is claimed has mechanical properties superior to manganese bronze and also improved resistance to corrosion and erosion.

Two Babcock and Wilcox oil-fired integral furnace boilers fitted with superheaters and tubular air heaters are installed and supply steam at a pressure of 450 lb per square inch gauge and superheated to 800 deg. Fah. The boilers, which supply steam to the main turbines, electric generator turbines, air ejectors and the turbo feed pumps, have a total heating surface of 14,872 square feet, a superheater heating surface of 1736 square feet and a total air heater heating surface of 16,080 square feet. Each air heater, which is of vertical tubular construction, has its surface arranged in primary and secondary sections. The temperature of the superheated steam is controlled by an attemporator, the coils of which are arranged in the water pocket or bottom drum of the boiler, the actual control being effected by a manually-operated valve. The feed water temperature is 310 deg. Fah. and the air temperature to the oil fuel burner is 339 deg. Fah.

Air for combustion is supplied by two fans, one per boiler, manufactured by James Howden and Co., Ltd. Each forced draught fan, driven by a 60 h.p. variable speed motor at 1175 r.p.m., is of single inlet pattern, 43·5in in diameter and is capable of delivering 24,250 cubic feet of air per minute at 100 deg. Fah. against a pressure of 9·25in w.g. Oil fuel is supplied to the boilers under the Wallsend-Howden pressure system, the oil fuel transfer pumps being supplied by Mirrlees (Engineers), Ltd. For providing steam for auxiliary purposes at sea and for harbour purposes there is an oil-fired vertical Cochran auxiliary boiler which operates under natural draught and provides steam at 120 lb per square inch. The boilers are fitted with CO_2 recorders, Bailey Jerguson Truscale water level indicators, and an electric salinometer and a densometer outfit supplied by W. Crockatt and Sons, Ltd.

The ship is equipped with Weir closed-feed system and regenerative condensers, which are underslung from the l.p. turbine casings. Each condenser has cupro-nickel tubes, a surface of 8000 square feet, and is supplied with steam at a rate of 54,000 lb per hour, and is designed to maintain a vacuum of 28·5in of mercury with the barometer at 30in, and the sea-water at a temperature of 60 deg. Fah. Condensate from the condensers passes through the "Lo-Hed" vertical electrically-driven extraction pumps, of which there are four, two working and two standby, each having an output of 55,000 lb to 87,750 lb per hour, to the two three-stage air ejectors, and the Weir combined low-pressure heater and drain cooler. This has a total surface area of 420 square feet and a capacity of 110,400 lb per hour with an inlet feed water temperature of 99 deg. Fah. and an outlet temperature of 168 deg. Fah. The feed water passes to two turbine-driven feed pumps taking steam at 800 deg. Fah. and each having an output of 135,000 lb to 175,000 lb per hour against a discharge pressure of 600 lb per square inch. The pumps discharge into a low-pressure heater which raises the temperature of the feed water to 230 deg. Fah. before passing it to the high-pressure heater, where the temperature is raised to 310 deg. Fah. Weir "Robot" feed regulators control the feed into the boilers and Davidson and Co. (Hexham), Ltd., has supplied a condenser vacuum gauge.



Arrangement of Machinery and Boiler Rooms

Auxiliaries

The evaporating plant is of Weir manufacture and consists of two 50-ton evaporators and one 50-ton fresh water distiller. Drysdale and Co., Ltd., has supplied the main and auxiliary circulating, general service and fire, bilge, ballast, fresh water and sanitary pumps, all of which are electrically driven. The same company has also installed its "Pneupress" system for the fresh and sanitary water services. There are three "IMO" forced lubrication pumps and the lubrication system includes Serck coolers and Alfa-Laval purifiers.

Located in the boiler-room is the sewage plant, supplied by Adams Hydraulics, Ltd., which consists of a pair of ejectors to port and another pair to starboard. Each ejector is of 75-gallon capacity and each pair is associated with an adjoining collecting tank. The ejectors, which automatically discharge when filled, are float actuated with automatic movement valves controlling the admission and exhaust of compressed air, which is provided by three compressor sets.

The "Leda" uses electricity very extensively for the deck machinery, steering gear, lighting, domestic services galley, engine-room pump motors, and the necessary power is supplied by three 350kW d.c. turbo-generators built by Peter Brotherhood, Ltd. They are installed transversely across the ship in a separate compartment placed between the engine and boiler-rooms. Each turbine is of single-cylinder, multi-stage, axial-flow impulse design, and takes superheated steam at 430 lb per square inch gauge and 790 deg. Fah., exhausting into an underslung condenser at a vacuum of 28·5in. The turbine drives an Allen generator through double helical gears to effect a reduction from 7500 r.p.m. at the turbine to 1250 r.p.m. at the generator, which is designed to give a normal continuous output of 350kW, 220V d.c. when running at this speed. For emergency purposes there is installed in a compartment in the house on the boat deck an 80kW generator set, supplied by J. and H. McLaren, Ltd., which is driven by a six-cylinder, radiator-cooled, four-stroke diesel engine developing 132 b.h.p. at 1000 r.p.m., and arranged for both air and electric starting. This set is capable of meeting the power requirements of the emergency lighting, emergency bilge pump, sprinkler system, fire-extinguishing system, and all navigational equipment.

Ventilation of the machinery spaces is effected by fans supplied by Keith Blackman, Ltd. Amongst the ventilating equipment are four 25in units, two being reversible, which supply the engine-room, while air to the boiler-room is provided by four 35in diameter fans.

A Self-Regulating Alternator

TO meet the need for small self-regulating alternators, Arthur Lyon and Co. (Engineers), Ltd., Stamford, has designed a range of self-excited salient-pole machines and associated static control gear to give close regulation at varying loads and power factors, without the use of automatic voltage regulators.

The "Stamford" alternator is a revolving-armature, salient-pole machine in which self-excitation is produced, without a commutator, by transforming and rectifying the a.c. output available from the slip-rings. In this alternator a sustantially constant voltage is obtained by means of a circuit (Fig. 1), which provides for varying excitation to compensate for the variations in voltage that are caused by changes in load and lagging power factors.

The diagram shows the principle as applied

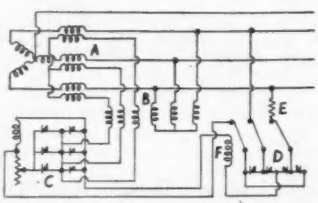


Fig. 1—Diagram of Three Phase Self Regulating Alternator

to a three-phase machine. Excitation of the field winding is derived from a three-phase rectifier *C*, which is fed from the secondary windings, connected in series, of a current transformer *A* and a voltage transformer *B*. The primary windings of the current transformers *A* are connected in the three phase lines and the primary windings of the voltage transformers are connected in between the lines.

At no-load the excitation is supplied by the voltage transformer. When the alternator is on load an additional component of current proportional to the load current is produced in the current transformer and provides the increased excitation needed to offset the fall in voltage that would normally accompany an increase in load.

The circuit also counteracts the tendency for the voltage to fall with decreasing power factor lagging. The current transformer has an air gap in its magnetic circuit which introduces a 90 deg. phase shift between the primary (line current) and secondary (excitation component). It follows that, at unity power factor the component of the field current (i_2, Fig. 3) due to the current transformer leads the component, *e*, due to the voltage transformer by about 90 deg.; the resultant field current is proportional to i_{f3}. At zero lagging power factor the excitation components due to the current and voltage transformers are approximately in phase and the resultant excitation i_{f1} is a maximum and the voltage compensation of the circuit has its maximum effect. At intermediate values of power factor represented by cos ϕ the resultant excitation is represented by i_{f3}. It will be appreciated that the direction of the resultant vectors has no significance since the excitation is rectified to direct current. For simplicity the vector diagram takes no account of armature resistance saturation and saliency of poles.

At starting, the low voltage produced by the residual magnetism would be insufficient to overcome the internal resistance of the main rectifier. Accordingly, a small single-phase auxiliary rectifier *D* (Fig. 1) is included in the circuit. This rectifier is fed through a ballast resistance *E* from two phase lines of the alternator and provides the initial excitation until the field current is strong enough to be maintained by the main rectifier. When this value is reached the auxiliary rectifier is automatically disconnected by a small Londex relay *F*, which is energised by the field current. This relay is the only moving part in the control equipment.

Apart from effecting the 90 deg. phase difference between the current and voltage transformer components, as stated above, the adjustable air gap in the magnetic circuit of the current transformer allows accurate adjustments to be made to suit any changes that may arise in the speed-governing conditions.

A typical engine-driven "Stamford" self-regulating alternator, with its control gear, is shown in the photograph reproduced herewith (Fig. 2). The control gear takes the form of a sheet steel cubicle housing the current transformer, voltage transformer, main and auxiliary rectifiers, change-over relay, hand field regulator, main switch and indicating instruments.

The alternator is a drip-proof, screen-protected

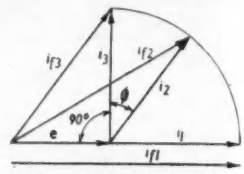


Fig. 3—Vector Diagram

machine in six frame sizes covering outputs from 60kVA at 1500 r.p.m., 50 c/s, to 6·5kVA at 1000 r.p.m., 50 c/s. The armature stampings are provided with axial ventilating ducts.

On a recent visit to the Stamford works of Arthur Lyon and Co., Ltd., we saw a sequence of tests demonstrating the voltage regulation characteristics of the Stamford alternator. In one series of tests an "A 15," 10kVA, dual-voltage, dual-frequency, engine-driven alternator was taken through a series of load changes, one-quarter, one-half, three-quarters load and full load, at 208V, 60 c/s, and at 415V, 50 c/s, the tests being carried out at both 1·0 power factor and 0·8 lagging power factor. Throughout these tests the difference between the maximum voltage and the minimum voltage observed was 3 per cent. Similar tests were carried out, with similar results at varying loads and at 0·5 power factor lagging.

In another series of tests an "A 15" alternator rated at 18·75kVA, 400V, 50 c/s, and an "A 18" alternator rated at 25kVA, 400V, 50 c/s, were subjected to parallel running, synchronising and load sharing tests, and their regulation was measured at various balanced and unbalanced loads.

The maker states that, with a speed variation of 50 r.p.m. in 1500 r.p.m., an overall regulation of ±1·5 per cent is normally obtainable, from no load to full load and from unity power factor to zero lagging power factor. For special applications this performance can, it is stated, be improved to ±0·75 per cent.

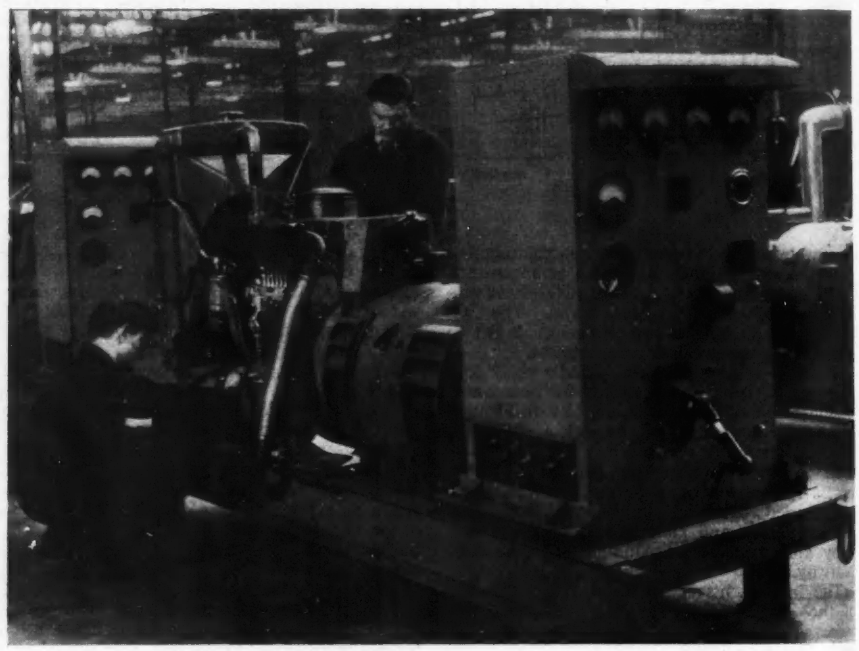


Fig. 2—Generating Set Incorporating a Self Regulating Alternator

The Institution of Electrical Engineers

REPORT OF THE COUNCIL FOR 1952–53

At the annual general meeting of the Institution of Electrical Engineers, which was held in London yesterday, May 14th, the Council of the Institution presented its report for the year 1952–53. Abstracts from this report are reproduced herewith.

A number of amendments to the by-laws of the Institution approved at a special general meeting of corporate members were submitted to the Lords of H.M. Privy Council, who allowed the proposed changes in an Order dated August 26, 1952. One of the amendments related to an increase in the subscription rates which came into effect on January 1, 1953. The additional income will be applied to meeting the increased costs which have followed the post-war period of inflation and, among other things, to the repayment to the capital reserve rebuilding fund of the amount represented by the annual interest on that capital, which during the post-war years has not been reinvested in accordance with the normal practice.

Membership

The growth in the membership of the Institution has continued during the session, the number of members elected being 2312, compared with 2295 during the previous session. The Membership Committee dealt with 2410 other applications, mostly for transfer from one class to another, making a total of 4722. On April 1, 1953, there were 28,867 corporate members and graduates on the register out of a total membership of 37,782.

The cases of 610 graduates whose membership of that class was affected by the change in By-law 15 which set an upper age limit for entry to graduate membership were reviewed by the Council; 165 applications for transfer to corporate membership submitted by graduates who were affected by the change in the by-law were approved by the Council, and extensions of graduate membership were granted in 227 other cases.

Although as a result of the change in By-law 15 the membership of a number of graduates lapsed on December 31, 1952, the total number of graduates increased during the year to 10,357 (9996 in 1951), and as these have complied with the examination requirements for associate membership, they will be eligible for transfer to that class when their practical training and responsible experience in professional work are of the required standard.

At the ordinary meeting held on February 5, 1953, it was announced that the Council had conferred Honorary Membership of the Institution on Sir Harry Railing, D.Eng., past-president, for his services to the electrical engineering profession and to the science, and for his services to the Institution.

The thirty-first award of the Faraday Medal has been made to Colonel Sir A. Stanley Angwin, K.B.E., D.S.O., M.C., T.D., B.Sc. (Eng.), past-president, for his outstanding contributions to the development of telecommunication in Great Britain and in the international and intercontinental fields.

* * *

In response to a petition, Her Majesty Queen Elizabeth II has graciously consented to become Patron of the Institution, an office in which she succeeds her father and grandfather.

* * *

Meetings

During the twelve months ending March 31, 1953, 1262 meetings of the members, the Council and the various committees were held in London and at the local centres. Nine ordinary meetings were held in London, with an average attendance of 269, as compared with 289 for the previous year. A joint meeting with the Institution of Mechanical Engineers, two extra meetings, the annual general meeting and a special general meeting were also held.

A public meeting was held at the Central Hall, Westminster, London, for the delivery of the 1952–53 Faraday Lecture by Mr. A. R. Cooper, M.I.E.E. The forty-third Kelvin Lecture on "Iron Atoms in the Service of the Electrical Engineer" was given in the Lecture Theatre of the Institution by Sir Charles Goodeve, O.B.E., D.Sc., F.R.S.

The membership of the four specialised sections continues to grow; particulars of this growth and of the activities of the sections are summarised below:

	Membership at March 31, 1953	Number of meetings	Average attendance (figures for last year in brackets)
Measurements Section ...	2150	19	122 (130)
Radio Section	4811	25	243 (150)
Supply Section	3691	8	144 (164)
Utilization Section ...	3639	8	129 (121)

Measurements Section.—Prominent among the meetings arranged this session was the Symposium on Insulating Materials held on March 16 to 18, 1953, which comprised a review of recent advances in the science and technology of electrical insulants, and a survey of current trends in the insulation of electrical equipment. The opening address was delivered by the president of the Institution, and thirty-two papers were subsequently presented in five technical sessions. Each session was opened by a rapporteur, who summarised the subject matter of the papers in that session. The total attendance was 1072, and several Continental research engineers were among the visitors.

The Annual Lecture was delivered on May 6, 1952, by Mr. R. S. J. Spilsbury, B.Sc. (Eng.), member, his subject being "The Electricity Division of the National Physical Laboratory."

The Section Committee are gratified at the number of papers which continue to be submitted, and during the past year ninety-four papers have been considered. These have included papers in the field of applied nuclear physics, and a group of three covering nuclear reactor instrumentation was read at the ordinary meeting on January 8, 1953, following a lecture by Sir John Cockcroft.

The summer visit was arranged on June 14, 1952, when the members of the Section, at the invitation of Sir John Cockcroft, visited the Atomic Energy Research Establishment at Harwell, and inspected the laboratories. The annual dinner was held at the Café Royal, London, on November 11, 1952; the company present numbered 286.

Radio Section.—The high-light of the year under review was the Convention on "The British Contribution to Television," held during the period April 28 to May 3, 1952. About 1300 members and non-members registered for the Convention, of whom 137 were visitors from oversea representing twenty-one different countries. The average attendance at each of the ten sessions was about 400. During the week twenty-six visits of technical interest were arranged, and among the social functions were a lunch and a television ball, attended by more than 500 delegates and guests.

The Section held a total of twenty-five meetings. The programme was varied and comprised, besides Dr. E. C. S. Megaw's address as chairman and the sessions of the Convention, seven Section meetings devoted to the presentation of papers, four discussion meetings, three informal lectures, including one by Mr. A. G. Jensen on "Recent Progress in Colour Television Technique in the U.S.A.," and a debate on the motion "That Broadcasting Hours Should be Drastically Curtailed."

Sixty papers have been submitted to the Radio Section Committee for consideration; this is about equal to the number of papers considered during the previous year.

A new venture for the Section was a dinner-dance held at the Café Royal, London, in January, 1953, when about 130 members of the Section and their guests attended. It is hoped that a function of this nature will take a regular place in the Section's activities.

Supply Section.—The Supply Section programme of events has included all the well-known and successful features with the exception of the annual lecture, which for the first time for many years was not arranged during the period covered by this report. Instead, however, a record attendance for the Section of 386 heard a paper entitled "275kV Developments on the British Grid System," by Messrs. D. P. Sayers, B.Sc., J. S. Forrest, M.A., D.Sc., and F. J. Lane, O.B.E., M.Sc. The authors subsequently received the Institution Premium (value £50), the highest premium award. Seven other Section meetings were held, and, in addition, one Supply Section paper was read at an ordinary meeting.

The total number of papers received by the Committee was thirty, as compared with thirty-three the previous year. In addition to those read at meetings, ten papers were accepted for publication only.

The summer visit was held at Southport on September 25 to 28, 1952, and was attended by 157 members and guests.

After joining with the Utilisation Section for two years in the holding of a dinner-dance, it was decided that in 1953 each Section should have its own function and arrangements have been made for the Supply Section dinner-dance to take place at the Café Royal, London, on April 21, 1953.

Utilisation Section.—Membership of the Section has grown steadily throughout the year, and a good attendance has been maintained at the eight meetings held. As has been customary during the past few years, one meeting was devoted to the reading of students' papers.

The annual lecture was delivered by Mr. W. F. Cartwright, who took as his subject "The Use of Electricity in a Modern Iron and Steel Works."

A dinner-dance was held at the Criterion, London, on January 13, 1953, at which 127 members and their guests were present. This was the first occasion on which the Section had held its own dinner-dance, previous functions having been held jointly with the Supply Section.

The annual summer visit was held on May 17, 1952, when 240 members and guests visited the Houses of Parliament, where they had lunch in the members' dining room. The party then proceeded by river to Greenwich, and were shown over the National Maritime Museum and the Royal Naval College.

Local Centres and Sub-Centres

Much effort has been put into the arranging of attractive and interesting programmes of meetings by the committees of the Local Centres and Sub-Centres; it is a matter for regret that their efforts received support from less than 25 per cent of the available local membership, and the Council wish to remind the many members who are not in the habit of attending Institution meetings that their annual subscription entitles them to attend all meetings of the Institution, whether in London or in the provinces.

Among the special events held during the year, the Convention on Electrical Contacts arranged by the East Midland Centre Committee and held at Loughborough College on April 7 to 9, 1952, was particularly outstanding and met with wide support and interest. A summary of the Convention will be published in the *Proceedings*, together with a number of papers specially selected and rewritten for publication.

The Federated Scottish Centre, with its three Sub-Centres based on Edinburgh, Glasgow and Aberdeen-Dundee, came into being on October 1, 1952, and experience to date has shown that the new arrangement is working well.

Students Sections

Facilities for members of Student Sections have been increased through the additional number of meetings and other functions which have been held in all parts of the country; but, unfortunately, there is little evidence that these activities have received the support they merit. There are now sixteen Students' Sections, and in addition interim Committees operate in the North Scotland and North Staffordshire Sub-Centres. Following a highly successful first meeting in Camborne, a provisional Sub-Committee was recently set up in Cornwall to organise further meetings in that area.

There was no foreign tour in 1952; instead,

efforts were concentrated on arranging a summer meeting in this country. This was to take the form of a week centred on Birmingham, followed by a week in London, but unfortunately it was not possible to proceed with the arrangements for either week because of lack of support. It is hoped to hold a tour in Northern Italy in July, 1953.

[The next section of the report, "Technical Investigations," deals with the work of the technical committees and it is followed by a section on "Joint Activities with Other Bodies."]

Education

Education and Training.—The Education and Training Committee have met twelve times during the year. Discussions have taken place with the Principal of the College of Aeronautics on a proposal to establish there a separate Department of Electronics. The Council have submitted alternative suggestions for the consideration of the Governing Body of the College.

The Council have been giving increasing attention to recruitment to the electrical engineering profession, and at their invitation the Public Schools Appointments Bureau held its annual conference in the Institution building in January, 1953. The Bureau devoted the greater part of the programme to discussion of careers in electrical engineering, and the Council collaborated by arranging for the presentation of a number of papers specially prepared for the information of headmasters and careers masters. Four of these papers gave—each with special reference to a main branch of the industry—an outline of the scope offered by careers in electrical engineering, and the fifth described the principal methods of qualifying as a professional electrical engineer. In assisting in this conference the Council received the active support of the British Electrical and Allied Manufacturers' Association, the Radio Industry Council, the Cable Makers' Association, Cable and Wireless, Ltd., the British Electricity Authority, and the British Broadcasting Corporation.

The Committee have been pleased to assist the City and Guilds of London Institute in their appointment of an Electrical Engineering Group Committee, which is representative of all branches of the electrical industry and of teachers of electrical engineering. The object of this Committee will be to keep under review the training of and, in particular, the availability of suitable courses for electrical craftsmen and technicians and, as a result, to make appropriate recommendations to the Technology Committee and the Examinations Board of the Institute.

Technological Education.—The Council have continued to press for the development of technological education, both in the universities and in colleges of technology. It is in the national interest that there should emerge a larger output of applied scientists in relation to pure scientists and, more important, that there should be a larger number of the two groups in relation to students graduating in other subjects. Apart from the additional provision that the Council consider should be made for applied scientists outside the universities, it is essential that a sufficient number be educated in the universities; increased and improved facilities for technological education in the universities require to be developed to meet the growing demands of industry. The Council therefore welcome the recent Government proposal to put further resources at the disposal of the University of London for the purpose of expanding the Imperial College of Science and Technology from its present student body of about 1600 until it reaches a figure of 3000 during the 1957–1962 academic quinquennium. The Council can appreciate the advantages of selecting this College for early and special assistance, but they would view the matter with concern if this were intended as the only university establishment for development. In their view, facilities must be widely spread throughout the universities, though not necessarily on the same scale at each; consequently they have noted with interest the indications of developments in several other universities.

The need to develop adequate facilities for technological education outside the universities is equally if not more urgent, and in their deliberations on the subject the Council have kept in close touch with the Councils of the Institutions of Civil Engineers and of Mechanical Engineers. Briefly, the Council consider that the desired improvements in this field can best be made by the development of appropriate facilities in a few colleges. Colleges to be chosen for this purpose should cater for a wide range of technological, as distinct from the more normal technical studies, and they should possess departments of equivalent standing in mathematics and in the physical sciences. The new industry-based sandwich courses now in operation in certain colleges should be one of the principal activities at these colleges. Advanced studies as well as facilities for research must also be available, and all the activities of these colleges must be so organised as to ensure the close association of student and staff acting with industry. The Council have also agreed with the two other Councils the name and nature of the new awards to be offered in the selected colleges.

EUSEC Conference on Engineering Education.—At the second Conference of the Representatives of the Engineering Societies of Western Europe and the United States of America (EUSEC), held at The Hague in 1951, it was agreed that an exploratory conference should be held on the subject of the education and training of professional engineers. Such a conference was held at the joint invitation of the Institutions of Civil Engineers, of Mechanical Engineers and of Electrical Engineers, in London in January, 1953. Delegates from Belgium, Denmark, France, Germany, Holland, Italy, Norway, Sweden, Switzerland, the United Kingdom and the United States attended. They were chosen by the respective engineering societies to include representatives of the universities and industry in each of the countries.

The primary object of the Conference was to promote an exchange of views on common problems and to obtain a better understanding of the methods of educating and training professional engineers in the countries concerned. Working sessions were held at the three Institutions in London, and visits were arranged to technical colleges, universities and industrial organisations.

At the concluding session of the Conference the delegates resolved to recommend to EUSEC that a second Conference on engineering education and training be held in 1954, and that for this purpose a glossary of terms used in engineering education and training in the participating countries be prepared. It was further proposed that the second Conference be authorised to consider the desirability of developing under the auspices of EUSEC a permanent conference concerned with engineering education and training.

Scholarships.—A new type of award—graduate scholarships—has been instituted for the purpose of encouraging graduates and others holding acceptable educational qualifications in electrical engineering to undertake a year of full-time post-graduate study, as distinct from research, at a university or other approved educational establishment. To fulfil this object the Duddell and Silvanus Thompson Scholarships are now offered for award as graduate scholarships as an alternative to their award as student scholarships. When awarded as graduate scholarships they each have an annual value of £400 and are tenable for one year. The Council have also increased the values attaching to the Duddell and Silvanus Thompson student scholarships. They now carry a grant of £200 per annum for three years' full-time study at a university or college.

The Scholarships Committee wish to make more widely known the fact that there is no upper parental income limit which may debar a candidate from financial assistance. The determining factors in making awards are personality, intellectual attainment and evidence of ability to profit from the course of study proposed.

Scientists and Technologists.—Replying to a recent question in Parliament, the Chancellor of the Exchequer, Mr. R. A. Butler, said that the number of scientists and technologists coming from the universities and technical colleges of Great Britain with degrees or Higher National Certificates and diplomas or their equivalent, in the academic year 1951–52, was estimated to be one in about 2600 of the population.

Hydraulic Self-Supporting Wheeled Escape

For some years it has been the practice in Continental fire brigades to employ wheeled self-supporting ladders instead of the wheeled escapes as used in this country, where the extended ladder needs end support.

Merryweather and Sons, Ltd., of Greenwich, which was recently commissioned to design and construct a number of self-supporting ladders together with the transporting vehicles for a Scandinavian brigade, was able to demonstrate the first appliance to be shipped.

The transporting vehicle is a fire engine based on a forward-drive "Commer" chassis (with left-hand drive) incorporating a six-cylinder, 109 b.h.p. petrol engine. The limousine body provides accommodation for four firemen in addition to the driver and officer. Amidships is a 500/800 g.p.m. single-stage centrifugal fire pump with suction inlet and delivery outlets and controls on both sides of the machine. Ample accommodation is provided for hose and gear. The most interesting feature of the appliance, however, is the rocking ramp at the rear by which the self-supporting fire escape can be lowered to or raised from the ground. These operations are performed with the aid of a hydraulic ram system combined with a rope and pulley gear which actuates the rocking ramp.

When the escape is required for action a head-rest locking gear is released and a small hydraulic valve at the nearside control panel is opened and the ramp carrying the escape is lowered to the ground. The speed of descent is governed by the extent to which the valve is opened. Actuation of a hand lever (also at the control panel) operates a hydraulic pump which supplies pressure to the rams and raises the ramp again and thus carries the escape up to its shipped position.

The self-supporting fire escape which weighs 35 cwt, is mounted on a rectangular carriage, the ladders being pivoted on twin swinging links. Two large pneumatic-tyred wheels are situated at the rear end of the carriage; at the other end is a smaller solid-tyred wheel, which enables the escape to be easily manœuvred by its towing handle. Four jacks are provided to give the escape a firm wide base when being used. The two jacks at the forward end of the carriage swing outwards to increase the width of the base.

The movements of the escape are controlled by two electric motors, each developing a maximum of 3 b.h.p. when fed by heavy-duty 24V batteries. One motor is used to elevate the escape, the other to extend it. Both elevation and extension can be carried out by hand in the event of emergency.

The escape proper consists of four steel ladders, each fabricated from steel tubes of special section and is similar in design and construction to the maker's turntable ladder escape. The escape will reach a maximum height 72ft 3in and a separate auxiliary ladder is provided to increase the overall height to 79ft, if necessary.

When the escape is to be elevated the movement of one lever releases the automatic brake and starts the motor driving the elevating winch which draws the heel of the ladder towards the carriage. The escape pivots on swinging links and its head rises until the required angle of elevation is reached. A similar one-lever action also controls the extension of the ladders. The lever releases the brake and brings the extension motor and winch into operation at the same time. Automatic pawls hold the ladder with rungs in alignment. The ladders can be housed by freeing the pawls and allowing the ladders to run back under the control of a friction brake. Suitable limit stops and safety devices are provided.

When the ladder is to be mounted on the carrying appliance it is wheeled to the transporting vehicle and the front wheel is made to engage the centre channel at the rear of the vehicle. When this wheel is positioned the rear wheels of the escape run on to the ramp runway, which is then shipped hydraulically. The escape is then moved forward slightly to reduce overhang and secured by a locking device. A crew of four men is sufficient to perform this operation.

A Two-Stage Air Compressor

We reproduce below a photograph of a two-stage, air-cooled air compressor unit designed for an output of 315 cubic feet per minute at 100 lb per square inch, which is now being made by Arpic Engineering, Ltd., Queenslie Estate, Glasgow, E.2. This unit is driven by an A.E.C. 11·3 litre industrial engine, which is a development of the commercial vehicle engine of 118 b.h.p. at 1400 r.p.m.

The compressor consists of four low-pressure cylinders arranged in vee formation with a central vertical bank of two high-pressure cylinders. Each of the cylinders has large cooling fins over which a constant flow of air is maintained by a large multi-bladed fan whilst the set is in operation. An intercooler is fitted between the first and second-stage cylinders.

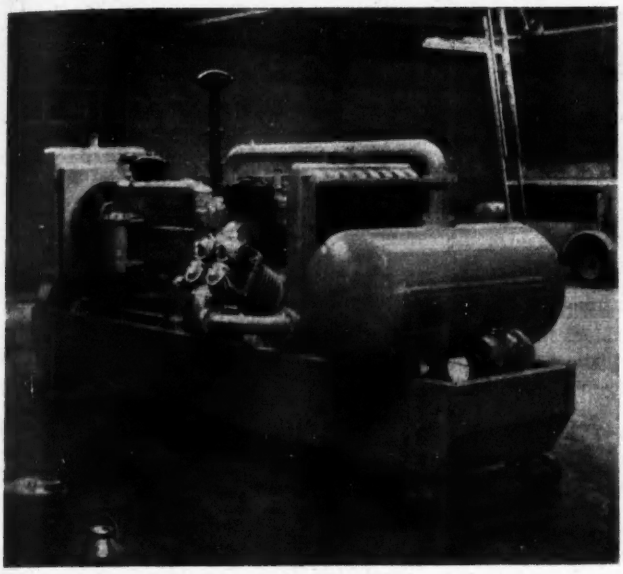
The compressor has an automatic air unloading system in which a pilot valve automatically operates unloading valves fitted to the high pressure cylinders, the intercooler and the air inlet port of the low pressure cylinders. In the cylinder unloading valves, piston and tappet operated lifters hold open the air inlet valve. The intercooler unloading device is a spring relief valve actuated by the pressure of air from the pilot valve and relieves intercooler air into atmosphere. At the inlet port the air flow is cut off. An automatic air receiver safety valve is a spring-loaded, tappet and piston unit, which relieves to atmosphere when air pressures exceed 110 lb per square inch approximately. Its valve tappet has an external lever for manual operation. An intercooler safety valve, set to operate at 45 lb per square inch, is of similar design.

The compressor is fitted with plate suction and delivery valves made from chromemolybdenum steel. Each valve is assembled on the stem of the base and operates against a tension provided by two slotted spring plates. Forged valve caps house the complete plate and spring assembly, which is secured by a slotted nut and split pin. Alignment of the ports in the valve components is provided by a locating pin on the valve plate.

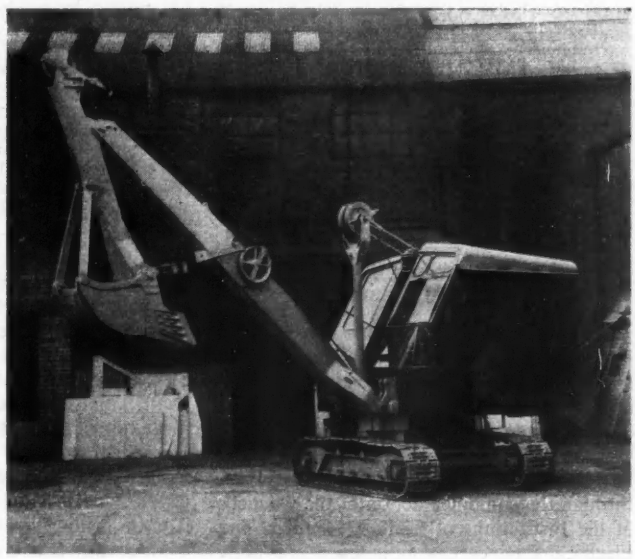
An air-cooled intercooler comprises an assembly of gilled copper tubes and in addition to the fitted safety valve has a combination unloading drain valve which drains the accumulated moisture whenever the compressor is unloaded or shut down. This valve remains open until the compressor operates, and then closes automatically.

The clutch is hydraulically operated from a simple push-button control valve and it is completely independent of the engine speeds. The compressor lubricating pump supplies the hydraulic power for the clutch and the compressor cannot restart under load. Stopping of the engine automatically disengages the clutch and if the compressor lubricating oil pressure fails for any reason the clutch automatically disengages so that the compressor is protected against continued operation without effective lubrication.

An automatic engine speed regulator reacts automatically to variation in the volume of air taken from the compressor so that the engine increases or decreases speed according to the number of tools being operated. Fitted between the air receiver and the air take-off manifold, this regulator consists of a chamber with inlet and outlet pipes. Within the chamber a disc and stem assembly is connected to the engine speed governor by a Bowden cable. The flow of air from the receiver through the regulator to the take-off manifold causes the disc and stem to move and operates the cable to the engine governor. The volume of air being used determines the movement of the disc within the chamber, which in turn regulates the engine speed governor.



Two-Stage Air Compressor



Universal Excavator

A Universal Excavator

Following a comprehensive series of trials under working conditions with prototype machines, production has now begun at the works of Priestman Brothers, Ltd., Hull, of the "Wolf" Mk. III B universal three-eighths cubic yard excavator shown in the illustration on this page. The new machine is designed to give quick and easy interchangeability between the equipments normally used for construction work—drag shovel, skimmer and luffing shovel.

The universal jib employed for these three equipments is of deep box section all-welded steel construction and in it the slot provided for passing the twin digging ropes through the centre of the jib has been eliminated. The two-part digging rope is reeved through a bail block, interchangeable on both the trencher and skimmer equipments. This interchangeability includes ropes, sheaves and jib details so that conversion from one equipment to another involves no loose parts, and the time required in converting is reduced to a minimum. There are two sizes of sheaves in all three equipments and their large diameters and improved method of reeving is intended to ensure a greatly improved rope life and operating efficiency.

A particular point in the new design is the elimination of the use of a forward drum in the case of drag shovel and skimmer operations. As a front drum is now required for the power crowd shovel only, it has been mounted permanently in the crowd shovel jib between the jib foot lugs. The crowd ropes are left permanently reeved on this drum, thus simplifying conversion of the machine to crowd shovel operation. The drag shovel and crowd shovel buckets are provided with a cast steel lip with socketed reversible teeth.

Power for the excavator is provided by a Dorman high-speed diesel engine arranged to develop 33 b.h.p. at 1050 r.p.m.

Dragline, grab and lifting crane attachments available with this machine operate from a common 32ft two-piece lattice jib, which can be extended by the insertion of a centre section to 40ft. The maximum discharge radius of the dragline using a ¾-yard bucket is 35ft, whilst the crane is designed to lift 3¼ tons at 10ft radius. The firm's "side dragline" attachment, which is used on land drainage operations, operates from a special 26ft channel jib designed to withstand the stresses and strains set up by its offset motion.

Another attachment which has been used with considerable success by agricultural and drainage authorities is the "Teredo" narrow bucket, designed to dig trenches for water mains and tile drains. This unit is specially suitable for handling sticky material, its positive mechanical ejector ensuring that the excavated material is forced out of the bucket.

South Africa's Economy

In an article on the effects of inflation on South African economy, in the second bi-annual edition of *Finance and Trade Review*, published by Volkskas, Ltd., it is stated that none of the ordinary negative phenomena usually associated with inflation has been experienced by South African economy during the last twelve years. On the whole the country prospered and is to-day economically in a stronger position than ever before. Production has been considerably expanded as compared with the pre-war capacity. The years 1939–52 will be known in the economic history of the country as the beginning of the great "industrial-revolutionary" period. The value of manufactured goods increased from £66,000,000 in 1937/38, to £269,100,000 in 1950/51, the value of mining products increased during the same period from £73,200,000 to £159,100,000, and the value of agricultural products increased from £45,100,000 to £213,000,000. Business investment in plant, equipment and in inventories, Government expenditure and personal consumption, is now substantially above any previous figures.

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THE PROFESSIONAL ENGINEERS APPOINTMENTS BUREAU

Each year since 1947 the Professional Engineers Appointments Bureau has, at about this time of year, issued a report on its work ; and the one that we published in our last issue follows similar lines to those which have preceded it. The Bureau, it will be recalled, was set up in November, 1945, through the combined action of the Councils of the Institutions of Civil, Mechanical and Electrical Engineers as an independent body operating upon a non-profit-making basis. Since then, as this year's statement makes clear, it has found appointments for over 1250 professional engineers. That number may not at first glance seem large. A better impression, however, of the amount of work involved is given by the figure of notifications of vacancies received, which has had a ruling level year by year of rather more than 1000 ; by the figure for nominations, 8751 for the year under review ; and by the ascertained fact that for a variety of reasons, such as insufficient increase of salary to justify a change, lack of future prospects in the job offered, difficulty of finding a suitable house and so forth, less than half the offers of employment made are actually taken up. What becomes very apparent when the series of annual reports is studied is that over the years the Bureau has performed a really useful service in helping firms to find suitably qualified engineers and in aiding professional engineers to find jobs suited to their qualifications. Year by year it has placed between 150 and 200 professional engineers in jobs suited to them ; and through its garnered experience it has proved able ,when asked, to offer tactful advice as to salaries that can hopefully be sought, or offered with a reasonable hope of securing a man with the required qualifications.

When the Bureau was set up soon after the war it was recognised that it could not expect at once to become self-supporting. For the sums obtained by making a charge to those successfully introduced to employment of 1 per cent of the first year's salary were clearly unlikely to meet running costs. The practice was therefore started from the beginning of asking individual firms—more particularly those which made frequent use of the Bureau's services—to make voluntary contributions towards is support. But such a source of income is seldom satisfactory. It is not that it may become insufficient, for, in fact, it has proved adequate. But when dependence is laid upon voluntary support it is the willing horse that contributes most of the cash. It is reasonable to suppose—we have not been shown the figures—that a number of more publicly spirited firms have, in fact, been meeting costs that should surely in equity have been shared by others. It seems therefore commendable to us that the Bureau is now setting out to become more nearly self-supporting than before. As its latest report reveals, besides levying a fee upon every engineer successfully introduced to employment, it is now charging fees of 1½ per cent of the first year's salary to employers whose vacancies have been satisfied through nominations made by the Bureau. No doubt some firms who have used the Bureau's services in the past without contributing to its funds will find the alteration irritating. But it seems to us unreasonable that the whole cost of running the Bureau should fall upon voluntary subscribers and those who are successfully found posts. Firms benefit by having vacancies satisfactorily filled just as much as successful applicants who obtain suitable posts. Upon maturer reflection we believe that firms originally irritated will find that their irritation is based, not upon a justified objection to the charge, but on a much less reasonable objection to the change!

Firms, we confidently expect, will soon come to think that the Bureau is to be commended rather than criticised for its attempt to become self-supporting and less dependent than formerly on voluntary contributions. But the relationship of the Bureau with Government Departments, to which in the past it has introduced numerous engineers, is more difficult. It has been laid down, no doubt by the Treasury, that the departments cannot meet the Bureau's new charges. That decision is less inexcusable than it seems at first sight. For when the Bureau was originally set up the departments agreed to notify vacancies to the Bureau on the understanding that no voluntary contribution to its funds should be asked of them and no charge made for the service. That agreement was, of course, made before the levying of any fee upon an employer was contemplated ; and it is continuing to be honoured by the Bureau. Yet under the new circumstances it must seem to an independent outsider, such as this journal, less than just. For in effect Government Departments are now expecting and receiving a free service from a private undertaking for whose services everyone else must pay. The Bureau is being placed *vis-a-vis* the Government in a position different from that of every other independent consultant, contractor or private agency in the country. It may, of course, be argued that engineering posts in Government Departments could be, and ought to be, filled through the operation of the Central Register. But the Professional Engineers Appointments Bureau has the advantage that it is smaller and more specialised and is thus often likely to prove more capable of careful selection in making nominations for departmental vacancies. The Treasury, we feel, should reconsider the matter, lest in its entirely estimable concern to keep down public expenditure it does an injustice to a private non-profit-making body that is now, very commendably, attempting to become self-supporting.

HIGH-TEMPERATURE GAS TURBINES

It is part of the guile of that apparently simple device the gas turbine that whenever a research worker peers out towards the future he is able to discern some environment or condition which will permit it to assert a superiority over other prime movers. Thereby he is enticed into attempts to overcome difficulties which, were the end less attractive, might appear too formidable. A fortnight ago we referred to the promising work that is being done towards making the burning of residual fuels practicable in gas turbines. Thereby the hope is held out that the newer prime mover may gain an advantage over the diesel in running costs if not in thermal efficiency. Another, and particularly tempting, route of advance is that towards the use of higher temperatures than present gas turbines can sustain. For in theory the open-cycle gas turbine when operating at temperatures of the order of 1200 deg. Cent. could attain thermal efficiencies higher than those within the reach of any other prime mover. But what difficulties stand in the way ! On Friday, May 1st, two papers were presented at the Institution of Mechanical Engineers descriptive of experimental work done with a cooled turbine. Those papers, together with the critical discussion that they evoked, revealed how difficult and possibly intractable are the practical, though not the theoretical, problems involved.

The use of ceramic blades to resist high temperatures seems to be now regarded as a less promising approach to the problem than that of adopting some means of blade cooling. Several systems of blade cooling

have been proposed and their feasibility tested on cascade rigs. There is boundary layer cooling, either by diffusion through porous blades or through slots in the blade profile, internal air cooling and liquid cooling, using the thermo-siphon principle, with or without air-cooled roots. Air cooling is the system that has been adopted by the authors of the papers presented to the Institution of Mechanical Engineers. The internal blade structure chosen is one employing longitudinal holes grouped within and as close to the profile as its geometry will allow. All stator and rotor blades were fabricated, employing a powdered metal technique, using as cores for the cooling passages a matrix of cadmium rods. The task of minimising the porosity in the sintered Vitallium alloy was made particularly difficult by this requirement. But eventually a blade having comparable creep and slightly inferior fatigue properties to those of the best high-temperature alloys available, was evolved. These blades have, in fact, also withstood so far without apparent defect several thermal shock cycles involving very rapid temperature changes between the limiting temperatures of the cycle. But calculations indicate that the tensile stresses thus set up are of the order of the rupture stress of the material. Heat transfer theory suggests the use of a large number of very small holes in such blades. But manufacturing limits, a possibility of fouling, and the extent of the spanwise pressure drop, actually determined their size and distribution, and the latter is such that it has not proved possible to obtain an adequate cooling surface area in the leading and trailing edges. At these positions at which the boundary layers are thin lamina and turbulent respectively, the heat transfer coefficients reach their highest values. Consequently, large chordwise temperature gradients exist. The spanwise temperature distribution is also severe, largely due, it is stated, to a temperature stratification in the gas flow itself. As a result of both gradients the more severe thermal stresses occur at about midspan, where thermal compression stresses as high as 15 tons per square inch are developed at the leading and trailing edges, whilst peak tensile stresses, at about mid-chord, reach 10 tons per square inch. These are rather alarming figures. But one of the major conclusions of the paper is that the compressive stresses induce a rapid local creep strain, and that when combined with the centrifugal and bending strains the resulting stress approaches zero, leaving the mid portion, the more easily cooled section of the blade, to take the load. But even if that conclusion can be safely accepted, the complexity and cost of blade fabrication and the difficulty of machining the required profile from the pressed blank remain serious practical objections to the use of this system of air cooling. Each rotor blade has thirty-three holes, 0·03in diameter, and the possibility of blockage seems a very serious hazard, no matter how efficient the filtering system employed. The cooling flow amounts to 4 per cent of the gas flow, as anticipated in the design. It would need, however, to be multiplied by the number of stages that had to be cooled in a practical turbine. With cooling losses of this order per stage there seems to be a real need to reduce the number of stages, and that action might well involve compromising the aerodynamic efficiencies of each stage.

The experiment has shown that a gas turbine to run at temperatures substantially higher than those now ruling can be made and operated. Unfortunately, however, it is difficult to draw any firm conclusions as to the degree to which the theoretical advantages could be realised in practice, because, as the authors admitted in the paper, the design adopted has certain defects. For example, the ducting system using convective cooling and annulus walls has little to recommend it. It was adopted simply to remove mechanical problems not solely concerned with the behaviour of the turbine. But the aerodynamic effects on the main gas stream of the entrained cooling air incurred in this arrangement can considerably influence the aerodynamic efficiency of the stage, and the consequences of the arrangement chosen were shown to be particularly deleterious. Similarly, the disposal of the blade cooling air at the blade tips necessitated rather large tip clearances and involved relatively high interference losses. This again was tolerated in order to avoid the mechanical difficulties of introducing shrouding in the experimental rig. It is, however, very apparent that to justify the cost of such a turbine the advantages would need to be substantial. Furthermore, the experiment has revealed that if this form of cooling were adopted the gas turbine must necessarily lose some of that simplicity and reliability that make it so attractive. For, in effect, each cooled blade becomes an individual heat exchanger and failure of flow of air through it may lead not only to failure of the individual blade but probably to much more severe damage to the turbine as a whole. Nor does there seem to exist any reliable mechanism for detecting a blockage before serious damage is done. Yet, despite these and other criticisms, the authors are to be commended upon their success in operating a single turbine stage with mean gas temperatures up to 1000 deg. Cent. and in reducing blade temperatures by 270 deg. Cent. In doing so they have suffered the experience that has befallen many pioneers. Like those who first explored the approaches to Mount Everest, they have revealed rather the difficulties that are opposed to further advance towards the summit than a promising road towards its attainment. Yet to reveal more precisely the nature of the problems needing to be solved is in itself a by no means inconsiderable contribution towards their eventual solution.

Obituary

F. W. BRACKETT

THROUGHOUT the whole of his long career as a mechanical engineer, Mr. Francis Whitwell Brackett worked in Colchester, and his death, which occurred there on April 30th, is deeply regretted. Until recently, Mr. Brackett was chairman and managing director of F. W. Brackett and Co., Ltd., which firm he founded in 1899.

F. W. Brackett was born in 1872 and spent his early years in the engineering industry in the works of A. G. Mumford, Ltd., of Colchester, the principal business of the firm at that time being the manufacture of pumps for marine use. In 1899, Mr. Brackett started his own business as a pump manufacturer. As he himself recalled, on the occasion of his firm's jubilee, his employees at the beginning consisted of a fitter, a turner and a labourer. By the end of the first five years there were twenty men on the payroll, a number which has now grown to over 200. As the business grew, Mr. Brackett extended the range of its products, and in 1914 began to manufacture, in addition to pumps, cooling water screens for power stations.

During the many years which Mr. Brackett spent in the business which he established, his enthusiasm, ability and charming personality endeared him to a host of friends. He was known and respected not only in the engineering industry of this country, but also by many concerned with power station and other contracts in countries overseas.

CLIFFORD GREEN

WE have learned with regret of the death of Mr. Clifford Green, deputy water engineer of Kingston upon Hull, which occurred, suddenly, on April 29th. He was sixty-three. Mr. Green was born and educated in Leeds, and began his engineering career in that city in 1906 as an apprentice with Hathorn Davey and Co., Ltd. Subsequently he held appointments with Beck and Co., Ltd., in London, and with A. C. Potter and Co., Ltd., of Grantham. While he was with this latter firm Mr. Green was responsible for the design and installation of new pumping plant for the Dunswell works of the Kingston upon Hull water undertaking. He joined the engineering staff of that undertaking in 1929 and six years later became deputy water engineer and manager.

Mr. Green was an associate member of the Institution of Mechanical Engineers, an associate of the Institution of Water Engineers, and a past-president of the Diesel Engine Users Association. For several years he had served as the chairman of the D.E.U.A. working costs committee.

Literature

Radio and Radar Technique. By G. T. STARR, M.A., Ph.D., M.I.E.E. London: Sir Isaac Pitman and Sons, Pitman House, Parker Street, Kingsway, W.C.2. Price 75s.

THE object of the book is stated to be "to cover the essentials of the radio and electronic field in one work." It appears to have been successfully achieved. Wisely there has been no attempt to develop the subject *ab initio*, and the reader is expected to be familiar with "the more elementary and well-known body of information . . ." obtained " . . . in the course work for a university degree or similar examination," and this applies not only to the technical but also the mathematical information. Whilst the underlying physical explanations are stressed, there is no hesitation in presenting results mathematically. The more lengthy analyses are contained in the numerous appendices, which occupy rather more than one-third of the total volume. In this way logical developments are carried through without undue digressions.

Chapter 1, "Methods of Communication and Physical Limits," deals with modulation theory (a.m., f.m. and the various forms of p.m.), noise, and radar principles; that is, with the variation of electro-magnetic

signals with time. Chapter 2, " The Electromagnetic Medium," treats of the spatial relation between the signal and the propagating medium. This discusses Maxwell's equations (their derivations being given separately in Appendix 13) and some of the developments therefrom, notably the free and guided propagation of radio signals. The M.K.S. system and the notation of vector analysis are used throughout. The properties of the ionosphere are briefly described, and the use of the Smith chart in both cartesian and polar forms is fully illustrated.

Chapter 3, " Microwaves and Short-wave Techniques " enlarges the discussion on guided waves, and treats largely of waveguides and waveguide components, discontinuities, bends and coupling devices. Chapter 4, " Antennæ," is concerned mainly with short and ultra shortwave aerials and arrays, including a very brief mention of dielectric aerials. Chapter 5, " Valves," deals comprehensively with valves of all types, including klystrons, magnetrons, and travelling wave tubes, stressing particularly the underlying physical principles. Chapter 6, " C.W. Circuit Technique," deals with steady state conditions and discusses the main theorems of passive networks, equalisers and filters, amplifiers (with particular reference to noise), and f.m. circuits. Chapter 7, " Waveform Circuit Technique," treating transient and pulse circuits and associated topics, concludes the connected text.

The rest of the volume is taken up with thirty appendices. These cover a wide range of topics, including an outline of vector analysis, a discussion of electro-magnetic theory, noise, network theory using mesh and nodal analysis, and operational analysis.

The author has deliberately avoided giving a series of applications for the theories presented. Thus, no " short cuts " are presented, and the help obtained from this volume is directly proportional to the effort the reader expends. There is an unfortunate tendency to use terms before they are defined (e.g., a " cheese " is mentioned on page 47 and first described on page 251). Mistakes in a first edition of a work of this size are inevitable, but are trivial and should cause no confusion in the readers for whom the book is intended.

The work as a whole is well produced and amply illustrated by line diagrams, which could, with advantage, have been increased considerably in size, although this would have resulted in an overall increase in an already bulky volume. Each chapter has a comprehensive bibliography, and there are frequent textual references to original papers. There is both a subject and an author index.

For the serious worker and for the advanced laboratory this volume should prove valuable. Although the nature of the contents precludes a simple treatise, Dr. Starr has produced a most rewarding one. It is unfortunate that the very high price will prevent its being as widely read as it might otherwise have been.

BOOKS RECEIVED

Fatigue of Metals. By R. Cazaud. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 60s.

The Loop Film. By R. A. N. Smith. London : Current Affairs, Ltd., 174, Brompton Road, S.W.3. Price 7s. 6d.

Electricity Tariff Handbook. London : Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 7s. 6d.

Physical Formulæ. By T. S. E. Thomas. London : Methuen and Co., Ltd., 36, Essex Street, W.C.2. Price 8s. 6d.

Handbook of Aeronautics : No. I, Structural Principles and Data. Fourth edition. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 45s.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

LIBRARY SERVICE FOR INDUSTRY

SIR,—It is obvious, in view of the vast extent of published technical information, that the foundations of any technical information service must be the organisation of machinery to locate, store and supply technical information. That is the province in which the technical librarian is the acknowledged expert and in which his techniques are indispensable. In technical information work, however, there also exists the other function, the nature of which Mr. Farradane has so clearly described. In the hands of a scientist-librarian of Mr. Arnold's calibre both functions can be combined, provided the unit of which he is in charge is small. But where, through growth or for some other reason, the two functions have to be separated, there can be no question but that the information officer function is more important than the library function. On this I am in complete sympathy with Mr. Farradane's point of view.

The intelligence officer versus librarian controversy has, however, very little to do with the point which I sought to raise in my original letter, and which seems to have escaped your correspondents. This misunderstanding has arisen, I think, because your correspondents are engaged in technical information work and some of them do not seem to realise that there is any other kind of information work than technical. Certainly they show no clear understanding of some of the essential differences between technical and what, for want of a better name, I may call commercial information work. There are, I think, two main differences. The first is that commercial information work does not depend to anything like the same extent on a vast body of literature of a permanent or semi-permanent nature. The methods of collecting, indexing and storing commercial information are far more rough and ready. Moreover, as Mr. Farradane has pointed out, much of the information is collected from sources other than a library. The second difference is, in my view, more fundamental. It is that the activities of a commercial information service may take it into such fields as market research, the interpretation and assessment of world economic developments, and the application of statistical techniques to a wide range of problems. It is, in fact, impossible to draw a clear-cut dividing line between commercial information work and the work of departments which commonly go under such titles as Commercial Investigations, Statistics, Economics and Statistics, and the like. The more a commercial information department enters such fields the less important becomes the library function, until in the last resort it vanishes altogether.

If both the technical and non-technical aspects of information work are taken together, it is readily apparent that such work is extremely wide in scope and varied in nature. It may find expression in a simple library with wholly routine functions, in a highly developed technical information service of the kind indicated by Mr. Farradane, in a general information department designed to assist not only technical and research departments but other departments also, or in a section which is predominantly or wholly involved in commercial, economic or statistical investigations. This is the universe to which I referred in my earlier letter. It is a universe propulated increasingly by research scientists, by scientists who have turned to techno-commercial work, by engineers, librarians, economists, statisticians, linguists, and the like. It comprises far more than the techniques of the librarian and the suggestion that the activities of all such expert personnel are mere off-shoots of librarianship is altogether too naive.

I do not wish in any way to belittle the activities and functions of the librarian in information work. Librarians are one of the pillars of the edifice. Nevertheless, they are not the edifice itself. Like Mr. Farradane, I wish to see collaboration and mutual understanding between librarians and others engaged on information work, but I see little hope of securing them so long as a large number of librarians believe, as they appear to do, that there is nothing in information work outside their own techniques of locating, collecting, storing and circulating information. I join with Mr. Farradane in thinking that there is.

A. R. SMITH

Wimbledon, London, S.W.19, April 29th.

Water Pollution Research

THE annual report of the Water Pollution Research Board of the D.S.I.R. for the year 1952, and the report of the Director of Water Pollution Research for that year, has now been published. The largest section of the report deals with work on the Thames Estuary. The subjects studied there include the distribution of salt water and fresh water, the effect of rough weather in raising the level of dissolved oxygen in the water, the relative importance in polluting effect of discharges of organic matter contained in fresh water streams, sewage effluents and industrial wastes, the particle size of deposits in different parts of the estuary, the important part played by suspended solids in contributing to the biochemical oxygen demand of estuary water, the effect of oxygen in inhibiting the reduction of sulphate to sulphide by bacterial action, and the catalytic effect of mud in promoting the oxidation of sulphide by oxygen in solution. Work at Birmingham during the year has confirmed that the four large percolating filters there, when treating sewage by alternating double filtration, operate more efficiently when each distributor revolves once in thirty minutes than when it revolves in one to five minutes.

Not only has the biochemical oxygen demand of the effluent from the filters with the slower rate of rotation been lower, but the degree of nitrification has been considerably higher than in effluent from the filters with rapidly revolving distributors. One of the main objects of the work at Birmingham now is to try to explain these differences. Results are given in the report of the operation, for thirteen months, of five small sewage treatment plants, each comprising a septic tank and filter, and treating sewage from some ten to twenty persons. The septic tanks tested included single rectangular, two-storied and double types. All of these gave substantially similar results, as did also the percolating filters, except for one fitted with a revolving distributor which required frequent attention. With a volume of filtering medium of 10 cubic yards for each ten to twenty persons, effluents of very good quality were obtained. Experiments made at Stivichall in conjunction with the Gas Research Board have now shown that spent liquor from the gas works at Hinckley can be treated in a percolating filter in admixture with sewage, in a concentration up to 3 per cent by volume, without causing much deterioration in the quality of the effluent. At Hinckley the hot gas is treated by electrostatic precipitation with the object of reducing the concentration of higher tar acids in the liquor. At the Hinckley works, also, retort house liquor is disposed of separately, and it is now proposed to begin experiments at Stivichall in which the liquor from Hinckley, with an appropriate amount of retort house liquor, is treated in admixture with sewage.

Work has also been carried out on the treatment of the black liquor resulting from the kiering of cotton, and experiments have been made on the effects of treating simple and complex metallic cyanides in admixture with sewage. The effect of various substances on the disinfecting action of chlorine in water was also investigated, as was the enumeration of *streptococcus fæcalis* (an indicator of fæcal pollution), and the removal of radio-iodine by processes commonly used at waterworks.

Boron in Steel

THE IRON AND STEEL INSTITUTE

No. II—(*Concluded from page 671, May 8th*)

AT the afternoon session on April 29th, Mr. H. B. Knowlton, of the International Harvester Company, read a paper entitled "American Applications of Boron and Other Low-Alloy Steels." Mr. R. Wilcock, of Samuel Fox and Co., Ltd., then presented a paper entitled "The Effect of Boron on the Mechanical Properties of Low-Alloy Steels." This paper has been published in the Institute's *Journal* for April, 1953.

Discussion

Mr. Brinley Jones (Climax Molybdenum Company, Ltd.): In endeavouring to sift and assess the potentialities for exploitation of medium carbon alloy heat-treated steels to be inferred from Mr. Wilcock's paper, we are drawn immediately, I submit, into a consideration of two widely differing principles of steel production and application, the one usually associated with practices of which the U.S.A. provides examples and the other more broadly instanced in British and European conditions. To take the first extreme of mass production, where the objective lies in the manufacture of huge numbers of identical parts of small or medium section for known service applications, and where it is possible to draw up specialist compositions and apply a rigorously controlled quench to individual components—everything suited exclusively for the precise job to be done—there seems no question whatsoever, in technical principle, that boron can be made to substitute on a very wide scale for the more conventionally used alloys—in short, where there is a streamlined correlation between steel production, heat-treatment, laboratory test and actual service—the four things indissolubly welded together, dovetailed the one into the other, integrated from start to finish. Everyone knows the admirable work carried out by the Americans along these lines, and I believe our distinguished visitor is not the least of the exponents of such activities. This kind of procedure has to be launched, of course, on a reasonably big scale in order to work.

Substitution as such, however, represents only part of the picture. Much depends upon whether one is driven by the compulsion of necessity to use boron. If not, the advantages are not nearly so attractive. On costs, for example, to what extent do we gain or lose by substituting boron? Other problems arise which bring troubles in their train, one of which would seem to be the difficulty inseparable from ultra-low alloy steels of the boron-containing type in securing analysis ranges sufficiently narrow to ensure regularity in properties. Unpredictability of distortion, for example, during heat-treatment has been reported to represent a major complication—more particularly with the carburising steels—such that, after several years of experience with the boron type, one U.S. authority has recently stated that "The excessive movement encountered in processing carburised gears is, in our opinion, still the most distressing problem to be overcome." Again, the prevention of wide variations in core strength for small variations in section size would appear to represent a very real problem for case-carburised parts generally. It is in no carping spirit that I would ask Mr. Knowlton—since it would genuinely assist in the further resolution of this subject—if he could tell me why some of the organisations in the United States, placed ideally, one would think, for using boron steels, have not, in fact, adopted them.

Going now briefly to the very opposite extreme from mass production, we have a situation here where there is a big production of alloy steels, notably heat-treated bars and sections for subsequent machining into miscellaneous parts. These are produced proportionately much more than in the U.S.A., I should say, not for some defined application—because the application may not be known to the steelmaker—but to conform to some standard mechanical properties specification which includes a notched bar requirement. It is true that for many applications service stresses may be such as not to justify the imposition of a toughness index of this kind. In others, however, conditions of stress concentration and the danger of brittle fracture will undoubtedly occur. Again, the steel supplier will not be apprised of the depth of machining applied in the production of innumerable finished components and the consequent exposure of the interior of bars to high stress. There seems little choice, consequently, but to apply generally some form of toughness figure as a safeguard for all. In these circumstances, it seems at first sight fatal that boron should cause such drastic deterioration of toughness in conditions where incomplete hardening is concerned. I am open to correction, but believe it would be an impossibility, without serious curtailment of output, to think in terms of full hardening throughout the section of a large proportion of the bar material thus supplied.

Mr. W. E. Bardgett (United Steel Companies, Ltd.): This morning Mr. Brown referred to the need for care in heat-treatment and perhaps I might appropriately raise it again now. I take it that the lower tempering temperature of the substitute steels may be one reason why care is necessary in heat-treatment. There is also the other point, that if quenching is not entirely satisfactory there may be loss in properties, as has been indicated by Mr. Wilcock. I take it that this special care which is being observed in heat-treatment may act in favour of the boron steels, and it would be interesting to know in what way that care is being taken. I should be grateful if Mr. Knowlton would explain the significance of the depth hardenability test on carburised specimens. We have in Mr. Wilcock's paper an excellent assessment of the manganese-molybdenum type of steel, which shows that the addition of boron results in an increase of rolling section for specific mechanical properties, but beyond a certain size the properties are inferior to those of the steel without boron. What actually is the advantage of the boron in terms of size or alloy saving? In what way can we take advantage of the boron hardenability?

Mr. A. J. K. Honeyman (Steel Company of Wales, Ltd.): I congratulate Mr. Wilcock on his very complete study of the effect of boron on a particular type of low alloy steel. As he indicates in his introduction, hardenability is not a sufficient criterion of the effects of boron on mechanical properties. All that hardenability determination can do is to serve as a guide to the probable rolling section. One of the slides which we were shown was taken from a paper which I wrote eight years ago on this very subject I suggested that boron increased the hardenability and I also suggested that up to 0·5in diameter there is no point in using it, because you get full hardenability without it; up to 2·5in diameter, oil quenched, the boron steel will be beneficial in all respects, since it is fully hardened (I use that in the sense of 100 per cent martensite). Between 2·5in and 4in diameter the mechanical properties may or may not be better, depending on the kind of transformation which has occurred in place of the full martensite transformation. Beyond 4in diameter, the boron steel is likely to be detrimental. It is in the range between 2½in and 4in diameter that the greater hardenability of boron-free steel may or may not result in improved mechanical properties, and it is therefore in this range that tests along the lines of those used by Mr. Wilcock should be carried out with a view to the possibility of increasing the rolling section of the steel concerned.

Dr. N. P. Allen (National Physical Laboratory): A statement made by Mr. Knowlton is one which, unfortunately, has had a great deal of currency and is sponsored by the majority of the leading American metallurgists and appears in their text books; it is actually, I think, on the way to being believed, and therefore it is necessary to contradict it in good time. The statement is this, that if you take a number of steels of different compositions and harden them completely and then temper them to different tensile levels, you will find that, according to the tensile level, the elongation and yield-point and the reduction of area and the impact value all fall in closely similar bands, and that is the basis of choosing steels on the ground of their hardenability. This statement is perfectly true in respect of the yield-point and the elongation and the reduction of area. It is only approximately true in relation to the reduction of area, however, and it is not even approximately true of the impact value.

This question of the value of boron will largely turn upon whether in fact we want the high impact values which are specified or whether we can get away with a lower impact value. That is a major point which has to be decided, and I think it is fair to say that the logical use of the impact value as a specification test has not been worked out, and we do not know where we stand. The sooner we find out the better. The curious fact is that all the scientific study of fatigue indicates that plastic deformation must take place before the material can suffer from fatigue, and yet the greatest difficulty with notch fatigue is found in those steels which have a very high ratio of elastic limit to tensile strength, and where the fatigue limit is usually well below the elastic limit as normally developed, and the designer would say "we do not contemplate that this material will undergo plastic deformation." There is a contradiction there, in that when something has failed by fatigue it has surely undergone plastic deformation at some spot. If a steel is in such a condition that when it undergoes plastic deformation it is also near its brittle strength it is somewhat dangerous, but there has not yet appeared experimental evidence to show that there is any connection at all between the Izod impact value as normally determined and the behaviour of any material in fatigue.

Mr. G. T. Harris (Wm. Jessop and Sons, Ltd.): Mr. Knowlton draws attention to the fact that boron affects other mechanical properties than hardenability. I wish to refer, therefore, to that class of steel used in gas

turbines, with anything up to 50 per cent of alloying element. We have carried out some experiments on the steel which has been used very largely in this country for jet engine discs, having the following composition :—C, 0·4 per cent ; Ni, 13 per cent ; Cr, 13 per cent ; Co, 10 per cent ; W, 2 per cent ; Mo, 2 per cent ; Nb, 2 per cent—something very substantially different from the class of steel which we have been discussing. Additions of boron of the order of 0·03 per cent are giving an improvement in creep strength, in a very highly alloyed austenitic steel of that sort, of the order of 20 per cent, something which would necessitate the addition of very considerable amounts of alloying additions. The point which I wish to make is that although a great deal of work has been carried out on the extremely low alloy steels, there is a very big field here which has hardly been touched, but it is a field where it might be possible to save a good deal of very expensive alloys.

Mr. C. L. M. Cottrell (British Welding Research Association) : One of the special features of low-carbon, boron-molybdenum steels is good weldability combined with a high yield strength. This type of steel has a high resistance to heat-affected zone cracking even when welded with electrodes having a high effective hydrogen content in their coatings. The good weldability of the boron-molybdenum steel, in my view, can be attributed largely to its low carbon content. The addition of boron gives a much increased rate of transformation in the intermediate range. This effect of boron presumably contributes to the strength of the steel by promoting an increased amount of this type of transformation at the cooling rates prevalent during manufacture. At the same time, the intermediate transformation is so rapid that, even at the high cooling rates associated with welding, transformation is completed above 300 deg. Cent. In other words, the effect of boron in this steel is most marked at lower cooling rates, which is very desirable from the weldability viewpoint. I should like to ask the authors whether they have any ideas on why boron should have this effect on the intermediate transformation ?

Mr. L. H. Toft (Mond Nickel Company, Ltd.) submitted some results of recent studies of the effects of boron treatment on the impact properties of N.E. 8630 and N.E. 8640 steels in both the fully hardened and partially hardened conditions. They did not wholly agree with results presented by Mr. Wilcock.

Mr. P. O. Bjoikman (A.B.B.A. Hjorth and Co.) : No doubt Mr. Knowlton will have some experience relating to machinability. I am thinking of drop forgings which weigh up to 15 lb and with dimensions up to 1in. If these forgings are made of alloy steel and then machined, we must normalise and anneal the forgings in order to get the best machinability. If these steels are replaced by ordinary carbon-manganese-boron steels can we gain something in machinability ?

Mr. R. J. Brown (Morris Motors, Ltd.) : On the question of heat-treatment, we have heard that it is necessary to have a closer degree of control over heat-treatment, and reference has been made to the effect of slack quenching and to a 25 per cent drop in the notch fatigue strength. Are we to assume from that that slack quenching does occur in practice in the U.S.A. and is tolerated ? My opinion is that in this country slack quenching is not usually tolerated because of its effect on notch impact results, but that is a point on which we should like some definite information. The question of grain size effects was raised this morning, but we had no specific answer to it owing to the shortage of time. I should like to ask Mr. Knowlton whether the boron-treated steels are of finer grain size than the equivalent alloy steels and whether there is any danger of running into machining difficulties due to the adverse effects of the extra dosage with aluminium ?

Mr. D. Hardwick (B.S.A. Group Research Centre) : From a few results which have been obtained so far, we can say that boron increases hardenability and that up to a tempering temperature of 400 deg. Cent., where the boron steel is through hardened and the non-boron steel only partially hardened, the maximum stress and the yield-point are superior in the boron steel, but above that tempering temperature they are the same. The impact value at all tempering temperatures is superior in the boron steel.

Mr. M. A. Kohn (French Iron and Steel Research Institute) : Our investigations on industrial casts show that boron has a favourable effect in every case when boron-treated steel is given a martensitic structure which is not produced in boron-free steel. Then, by boron addition, it is possible to increase the properties of the steels in intermediate sizes, the limits of which vary from steel to steel according to the alloying element contents. To improve the mechanical properties of the steel by boron addition is a valuable result, but whether to use this steel is another question, for mechanical properties are not the only point to be considered. At first in France we thought, from American information, that the effect of boron was favourable in carburising grades for parts used in the automotive industry. However, tests made with the co-operation of two important automotive firms showed that these steels were not convenient for these parts. They cannot be austenised or carbo-nitrided at the temperatures generally used in continuous production. Furthermore, steels used in this industry have already very low alloy contents and it does not seem possible further to reduce their nickel and chromium contents. Now, in France, it seems that the most convenient boron grades are the steels used for heat-treated parts where the main characteristics wanted are a high tensile strength in the whole of the section associated with good impact properties. Further tests are to be made for that purpose. Boron steels have properties which seem to be useful for some applications, apart from the saving of alloying elements. Tests must be made in various ways to investigate all the possibilities of boron steels.

Mr. G. Mayer (Mond Nickel Company, Ltd.) : During the course of some work several years ago on the effects of boron in nickel-containing steels, an interesting effect was observed which did not appear at the time to merit further attention, but I am inclined to believe that it might give a lead to a very useful application of boron. The effect was that of raising the elastic limit of a 0·2 per cent carbon steel of the weldable kind. At the time of the investigation emphasis was placed on the yield strength of high-tensile welding steels and a 0·2 per cent carbon, 2 per cent nickel, 0·2 per cent molybdenum steel was one of the best available. This steel had a 0·5 per cent proof strength of about 30 tons per square inch in the as-rolled condition or when normalised as ½in thick plate, but the yield was of the continuous type and the elastic limit was low. The elastic limit could be raised, however, by tempering at 450 deg. Cent. Tests on experimental melts showed that half the molybdenum in this steel could be replaced by boron without loss of mechanical or welding properties, the boron being added as Silcaz, preceded by deoxidation by 0·1 per cent aluminium. In discussing the effect of boron on the mechanical properties of steels where its effect on hardenability is not involved, as when considering fully-hardened and tempered steels, the type of boron addition alloy used should not be overlooked. For example, it has been claimed—several speakers have already referred to this—that boron improves the impact resistance of fully-hardened and lightly tempered steel. We have tested this claim and we found that a small increase in impact value was effected when the proprietary alloy Silcaz was used, but a similar increase was also obtained by the use of a synthetic Silcaz mixture, with the boron content omitted. That shows, I think, that this effect may not be due to the boron at all, but may be related to the deoxidation practice. A more intense deoxidation is carried out when boron is being added, and it may be that deoxidation practice which is responsible for these higher impact figures in the fully-hardened and lightly tempered condition, rather than the boron *per se*.

Mr. T. R. Middleton (English Steel Corporation, Ltd.) : I could think of many questions to ask about what is being done in the U.S.A., but owing to the lateness of the hour I shall confine myself to one question only. We were told this morning that about 8 per cent of alloy steel for general engineering purposes was being boron-treated. I wonder what has happened to the other 92 per cent ? I cannot think that more boron-treated steel is not being made through any lack of salesmanship on the part of Mr. Knowlton. There may be other reasons. Some of the steels may not be, and I suppose certainly are not, types which will respond to boron treatment. I am sorry I did not ask this morning, when Mr. Rohl was here, whether there was not another reason, namely, whether there are some steelmaking difficulties which will cause steel manufacturers to say "No, we cannot supply these boron steels." I have in mind that where steels are aluminium-treated in the ladle and by our standards are excessively treated with aluminium, one can run into trouble in an exaggerated form. For example, an aluminium addition to quite a number of qualities of steel gives troubles in casting and cracking and there may be others. I should be interested to hear more about that.

The authors replied shortly and the meeting ended.

Books of Reference

The Mineral Resources of the World. By W. V. Royen and O. Bowles. London : Constable and Co., Ltd., 10, Orange Street, W.C.2. Price 70s.—This volume was originally compiled in the United States, and the many sources consulted in its preparation included the files of the Bureau of Mines. Its emphasis falls upon the major mineral deposits which are being exploited at the present time, and the selection of the twenty-nine commodities whose use and occurrence is reviewed was determined largely by the extent to which they enter into international trade. The text is intended to review succinctly the most important technical factors that govern the exploitation of the various mineral deposits as shown on the maps and graphs. It is pointed out that this volume does not present a current statistical record of mineral production. The various commodities examined are as follows :—Coal ; petroleum ; water power ; iron ore ; manganese ; nickel ; chromite ; tungsten ; molybdenum ; vanadium ; bauxite ; copper ; lead ; zinc ; tin ; mercury ; gold ; silver ; the platinum-group metals ; uranium, radium and thorium ; phosphate rock ; potash ; sulphur and pyrites ; salt ; diamond ; asbestos ; fluorspar ; graphite ; and mica.

Electrical Research and Agriculture

Last week, from May 4th to 8th, the Electrical Research Association's Field Station at Shinfield, near Reading, was open for inspection by those who are interested in the use of electricity in agriculture. Visitors to the field station saw some of the research work that is being done to extend the use of electricity in crop and seed drying, in horticultural plots and glasshouse heating, in dairy and poultry farming, and in the harnessing of wind power.

THE Rural Electrification Section of the Electrical Research Association was set up in 1938 to develop equipment and operating techniques for the use of electricity on the farm and market garden. The aim was to meet the needs of the farmer and grower by developing uses for power with load characteristics suitable for electricity supply on an economic basis. To provide facilities for the more basic research work a field station was established at Shinfield in 1945. Among the advantages of this site was its proximity to the Reading University Poultry Department and the National Institute for Research in Dairying—two neighbours whose collaboration has been of great value in the E.R.A. research programmes.

Electrically-Driven Tractor

The majority of the field exhibits to be seen on the open days were confined to the more fundamental research work and some of the early phases of practical application. But to give a better indication of the scope of the field station's activities a display was exhibited summarising the full extent of the research programme. This display was arranged in three parts ; the first showed equipment and methods which have been developed commercially from past researches ; the second group dealt with current research work, and the third showed the possible future development of present work.

Among the past achievements illustrated in this display were methods of barn hay drying ; a small automatic hammer mill developed for farm grinding ; an immersion unit for sterilising small quantities of soil ; various methods of soil warming in frames, greenhouses and cloches. Another important contribution to rural electrification was the specification for an 11kV rural distribution line which was adopted in the British Standard 1320 : 1946, " High-Voltage Overhead Lines on Wood Poles for Line Voltages up to and Including 11kV."

Turning to the field exhibits themselves, the visitor was able to see researches in progress in horticultural applications, barn and field equipment for crop drying, applications concerned with livestock and specialised work, such as pest destruction by high-frequency energy. Some of the work is referred to in the following paragraphs.

One of the interesting exhibits was an electrically operated tractor which is illustrated herewith. This tractor has been in use for four years at the field station. It is designed for general cultivation work on a small holding and can work in standing crops. The aim of the investigation is to develop a method of getting a power supply to the tractor which is an electrically driven modification of a petrol-driven tractor. The tractor is powered by a 6 h.p. totally enclosed motor which drives the tracks through a variable-speed hydraulic coupling and is supplied through a special light cable from a central tower. This tower can be seen on the left of our second illustration. It consists of 35ft high twin tubular legs and stays and carries sufficient festooned cable with tensioning weights to give the tractor a radius of operation of 110 yards, which is sufficient to cover a square holding of 5 acres. The cable is kept in tension, at a minimum height of 3ft above the ground and the cable lead-in to the tractor is shown in our illustration. Three alternative designs of light four-core cable to a specification which provides adequate strength in tension, are to be tested.

One of the experiments in progress in the large greenhouse on the right of the illustration is concerned with the possibility of saving fuel in tomato growing by warming the soil to 57 deg. to 60 deg. Fah. and reducing the minimum night air temperature below the usual 60 deg. to 65 deg. Fah. Four compartments are used for this experiment, two being soil-warmed and two acting as control. Two of the compartments are heated by low-voltage conduit and two by mains voltage tubular heaters. Present indications are that the same total crop is obtained (but not so early) at 50 deg. Fah. air temperature with soil warming as at 60 deg. Fah. without soil warming.

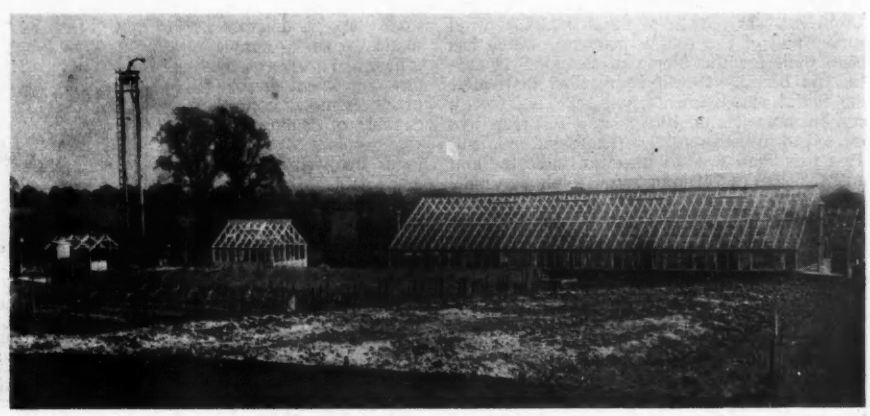
The field station houses a heat pump installation designed and erected by the E.R.A. with the dual object of heating the newer of two laboratory buildings and of yielding useful experimental data on the economics of heat pump operation. To allow the performance of the heat pump to be compared with more thodox orheating media the two laboratory buildings have been given similar thermal characteristics.

Brine tanks take heat from the surrounding ground which constitutes the low-temperature heat source. With a 7·5kW electric motor driving the heat pump it has been possible to apply 28kW for heating the laboratory building ; this output represents a performance energy ratio of 3·8. In this heating system the hot water is stored at 120 deg. to 125 deg. Fah. in an insulated tank and is circulated through panel radiators under the control of a time switch. A thermostat in the storage tank controls the operation of the heat pump motor. The instruments include a source water flow indicator and the daily and weekly times of operation are recorded so that the load factors can be calculated. The energy consumed by the compressor motor and each of the circulating pumps is separately metered and the daily readings are correlated with weather observations made at Shinfield.

A practical application of the heat pump in the dairy was shown in the form of an experimental set-up designed to demonstrate the possibilities of cooling milk and heating water. Preliminary tests suggest that this heat pump arrangement is capable of cooling 35 to 40 gallons of milk and of using the heat abstracted, to raise the temperature of 25 gallons of mains water to 130 deg. Fah. In this experimental equipment the compressor unit is hermetically sealed and immersed in the hot-water storage tank so that the heat " losses " of the compressor and motor are recovered. Chilled water from the heat pump cycle is stored in a lagged container and provides the cooling medium for the milk cooler which is of conventional form.

One of the permanent buildings at Shinfield is a crop drying laboratory which houses experimental equipment for studying the drying characteristics of different materials. The apparatus consists of ducting whereby samples can be subjected to varying conditions of air flow and, at the same time, continuously weighed. Samples can be tested up to a depth of 1ft. The material is placed in a section of the ducting which is connected to the rest of the ducting circuit by flexible bellows, and the " test " section is weighed continuously on an Avery machine. The incoming air is first filtered and dehumidified and then a controlled quantity of moisture can be added. The test section of the circuit, which contains the sample, is by-passed under the control of solenoid-operated dampers until the required stable conditions of air flow are established. The wet and dry bulb temperature of the drying air and the air flow through the sample can be varied over a wide range of values. Measurement of the air flow is made by a Simmons hot-wire anemometer.

Adjoining this laboratory there is an experimental crop drier which is being used for investigations on the pros and cons of wilting wet grass



Part of the Field Station at Shinfield

without using supplementary heat. In this equipment the grass is dried in a container which is suspended from a hydraulic mechanism whereby the weight of the grass is recorded continuously during the drying process. For the purpose of the present investigation the first part of the drying operation consists of blowing comparatively large quantities of cold air through the grass, the moisture content of which is thereby reduced, say, from 80 to 50 per cent. Then, to complete the drying, the air flow is greatly reduced and some supplementary heating is introduced.

In the general laboratory at Shinfield one of the investigations is concerned with the use of high-frequency electric fields to destroy biological pests in foodstuffs. This work is likely to be of practical significance in view of the estimate that the loss of foodstuffs by insect attack before and after harvesting is 30 to 40 per cent of the total produce. The apparatus used for this work is similar to that which is employed in industry for high-frequency dielectric heating. So far it has been established that pests such as the weevil can be destroyed in grain without damaging the latter : the heating effect is selective and depends on the dielectric constants of the parasite and the host. A study is being made of the use of pulse-modulated high-frequency electric fields. The present indication is that the lethal effect is a function only of the temperature and its duration and is independent of other factors such as frequency.

It is thought that this method of pest extermination may prove to be economic. On the basis of present knowledge it is suggested that a 25kW high-frequency equipment could be designed to handle 4000 lb of grain per hour at a cost of about 4s. 6d. per ton.

Poultry researches which are being conducted at Shinfield in co-operation with the Poultry Department of Reading University include studies of the effect of illumination on egg laying. Whereas the usual commercial method of stimulating egg output is to use artificial lighting to extend the effect of daylight by giving a total " day " equivalent to fourteen hours, the purpose of the present research is to produce the same stimulus by short flashes of high-intensity light just before dawn. Experiments conducted over two years suggest that two twenty-second flashes of 1500W of tungsten lighting—one at about 4 a.m. and the second at 4.30 a.m.—are as effective as 100W of extended daylight. In each case the average figures were nineteen eggs per hen per month with an average food consumption of 8 oz per egg, compared with an average of sixteen eggs per month and 9¼ oz of food per egg under normal laying conditions.

The experiment is divided into five parts : first, birds in fold units ; secondly, a closely controlled and replicated test with birds in batteries ; thirdly, tests with birds working two twelve-hour shifts on deep litter and shut off from natural daylight ; fourthly, tests with birds on deep litter, and fifthly, tests with groups of birds subjected to varying numbers of flashes.

For the purpose of the open days the wind power researches carried out by the E.R.A. at Shinfield were the subject of a display based on models, wind survey data, and some of the instruments used to obtain these data. The main exhibit was a model of Costa Hill, Orkney. Costa Hill was the site of the first E.R.A. wind survey and of the 100kW generator which has been built for the North of Scotland Hydro-Electric Board. It will be recalled that, after the initial measurements had been made with cup anemometers on 10ft poles, a 70ft mast was erected to investigate the vertical wind gradient. This mast had a wind direction indicator and anemometers at 70ft and 35ft. A photographic recorder, taking photographs of the instrument readings at half-hourly intervals, was built for use with this mast. Later, when it had been decided to build the 100kW generator on the site, a 120ft mast, with a cross arm at 80ft, was installed.

This mast is designed to orientate itself in synchronism with the orientations of the windmill generator some 80 yards away. It carries a number of cup anemometers and gust-measuring instruments and its purpose is to provide information on the variations, in time and in space, of the wind meeting the generator. Quick-response recorders are used with the instruments and there are matching electrical instruments to measure the output of the machine.

To ensure that records would be obtained of maximum wind speeds attained in the destructive gales such as those which occurred in January, 1952, and again in January, 1953, a specially constructed cup anemometer, calibrated up to 150 m.p.h. (or 200 m.p.h. with an alternative cup system), was installed. With this instrument a maximum wind speed of 125 m.p.h. was recorded on January 31, 1953.

The model showed the locations of the instruments on the hill in relation to the generator itself as well as the construction of the masts and instruments used.

Research work on small-scale generation of electricity by wind power is controlled by a sub-committee of the E.R.A. Wind Power Generation Committee. The scope of the work includes performance tests on small capacity, commercially available plants suitable for supplying electricity to small farms and isolated buildings. The sub-committee is also concerned with studies of loading schedules and methods of using the output of generating plants to make the best use of the wind energy available over the whole year.

A Fluid Flow Synchroniser

It is necessary in an aircraft to provide synchronisation of certain complementary mechanisms, particularly those concerned with the control surfaces. This requirement is immediately apparent, for instance, in the case of flap operation, where the assymmetrical lowering or raising of the flaps on either wing would be disastrous. Normally, to ensure flap synchronisation, an interconnecting torque tube is used and in other cases other forms of mechanical linkage are involved. This method of synchronisation can be attended by both mechanical and structural complications and we learn from British Messier, Ltd., that it has fitted to several recent aircraft a hydraulic synchronising unit (Fig. 1) which is stated to be the first of its kind.

The general arrangement of the unit is shown in Fig. 2 and comprises a light alloy body housing a steel piston which operates inside a suitably drilled sleeve. The orifices in the sleeve open into two pairs of simple inner and outer non-return valves. The piston is attached to a differential mechanism provided with two shafts for attachment of two levers. Jacks *A* and *B* (Fig. 3) or part of the mechanism they operate, are connected to the two levers on the synchroniser (shown diagrammatically as a simple differential lever) by any convenient double-acting remote control capable of dealing with the nominal operating loads involved without appreciable backlash. Synchronisation to the order of 5 per cent can be guaranteed, including a 3 per cent allowance for the backlash of the remote control.

During operations fluid entering the unit passes to both jacks via the two outer non-return valves. If the two ends of the lever move equally (i.e. the jacks are synchronised), the piston remains central ; should one jack lead the differential lever translates and moves the piston over to throttle the flow to that jack.

When the jacks move in the reverse direction, the direction of movement of the piston must be reversed to throttle the jack which tends to lead. This is accomplished by isolating part of the piston by means of the two outer non-return valves and allowing the remainder of the piston to operate through the opening of the inner non-return valves.

In a synchronisation installation of this form the unit would be connected to the " down " side of both jacks, the other side of the jacks

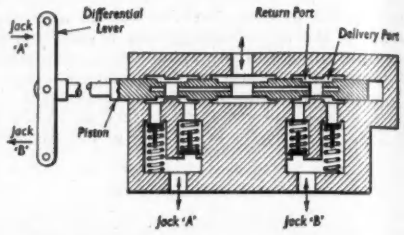


Fig. 3—Principle of Operation

being connected to the selector. This arrangement gives synchronisation in both directions of travel of the control surface jacks although with following loads the jack may cavitate in the " up " direction, thus losing synchronisation.

Where positive synchronisation in both directions of travel is required, it is desirable to control the reverse flow from a jack to prevent cavitation. This is accomplished by fitting two synchronisers per pair of jacks. In such a case the two inner non-return valves can be dispensed with, as the unit passes free flow in one direction.

A number of variations have been developed to meet particular requirements and all are suitable for operating pressures of 4000 lb per square inch.

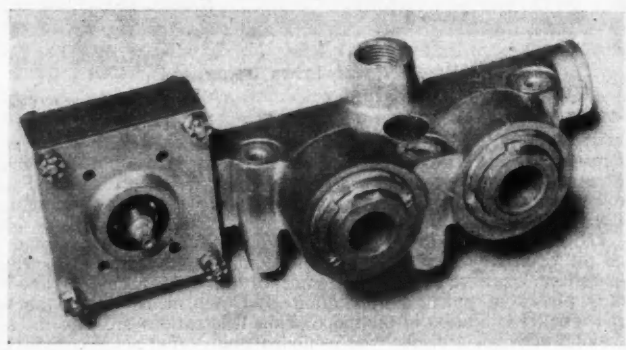


Fig. 1—Fluid Flow Synchroniser

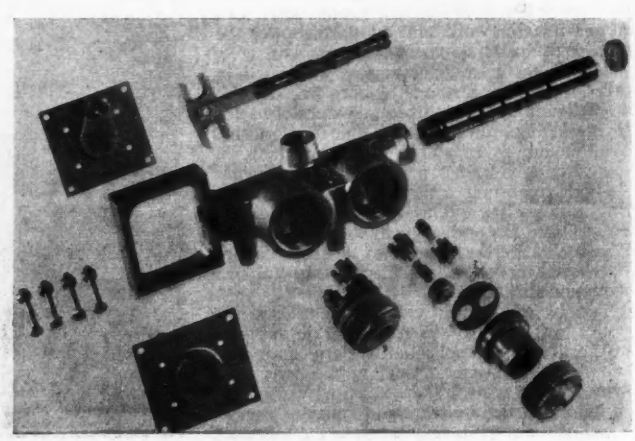


Fig. 2—Component Details

Brighton "B" Power Station

No. II—(*Concluded from page 665, May 8th*)

Brighton "B" power station at Southwick has a potential generating capacity of 330MW, four 52·5MW sets and two 60MW sets. Two of the 52·5MW sets are commissioned, the third set should be on load this year and the fourth in 1955. The boilers are pulverised fuel fired and the stop valve steam conditions are 900 deg. Fah. and 900 lb per square inch. The station output, generated at 11·8kV, is transformed to 132kV, for connection to the grid. Overhead lines connect the first two sets to the Fishergate substation and 132kV cables laid in a tunnel will connect the remaining four sets to the Southern Cross substation.

As we mentioned briefly in last week's article, the flue gases from each boiler are cleaned in a mechanical grit arrestor, followed by a Sturtevant dust precipitation plant of tubular design, housed in reinforced concrete casings.

Each of the electrostatic precipitators is split into three self-contained sections by concrete partitions. All the sections can be isolated mechanically by dampers between both the inlet and outlet flues and the body of the casing, and electrically by the isolating switches in the high tension house. With this arrangement one section can be closed down whilst the full volume of gas is handled by the remaining two sections, so that routine maintenance can be done whilst the plant is in operation.

In the precipitator tubular receiving electrodes form the treatment zone through which all the dust-laden gas has to pass. A self-cleaning side inlet flue is built as an integral part of the casing and runs the full length of the plant. The dust-laden gas from the boiler air heaters enters this main flue and then passes to the main body of the structure through damper controlled inlet tube banks and at the same time passes downwards to the lower ends of the tubes, where it turns upwards through the tubes and comes under the electric field set up by the high potential difference maintained between the discharge and receiving electrodes. This causes the solid matter contained in the gas to be driven to the tube walls, the clean gas passing out of the top of the tubes through the damper controlled outlet ports in the main outlet flues. Suitable rapping gear is provided to maintain the tubes and electrodes in a reasonably clean state.

The clean gas chamber, that is the portion above the tube banks, is completely sealed off from the dirty gas chamber below, which ensures that the whole of the gas must come under the ionising influence of the electrodes before leaving the precipitator on its way to the stack. The low dust burden entering the precipitator from the mechanical collector, combined with the high efficiency of the precipitator, brings about a very low outlet dust burden in the gases passing to the stack.

The high tension equipment supplied with these large Sturtevant precipitators embodies a mechanical rectifier. It consists briefly of a low tension control panel, voltage regulator, oil-immersed step-up transformer and a mechanical rectifier to obtain the high tension uni-directional current required for efficient gas cleaning. In each high tension house, situated between each pair of casings, there are two sets of high tension equipment, one per precipitator. These sets are interconnected on the output side so that either set can operate on either precipitator. In addition there are three isolating switches (one per section) for each precipitator.

At present there are two 52·5MW steam turbo alternators installed and in operation at Brighton "B" station (Fig. E). The turbines are three-cylinder, 3000 r.p.m. impulse reaction machines made by Richardsons Westgarth, Ltd. They are designed for normal stop valve steam conditions of 900 lb per square inch and 900 deg. Fah. and for a vacuum of 29in at maximum continuous rating.

The h.p. cylinder has one row of impulse blading and twenty-four rows of reaction blading and the i.p. cylinder has nineteen rows of reaction blading. The l.p. cylinder is arranged for double flow, with six reaction stages in each. For feed-heating purposes there is a drain cooler, l.p. heater, gland heater, deaerator and three stages of h.p. heating; the total quantity of steam bled for feed heating is 122,000 lb per hour and the final feed water temperature is 385 deg. Fah. The condensers, which are also of Richardsons Westgarth manufacture, are twin-shell units designed to handle 46,000 gallons of circulating water per minute per set (including oil and air coolers), with a c.w. temperature rise of 12 deg. Fah.

There are two Mather and Platt condensate extraction pumps per set, each being rated for 875 gallons per minute with 185ft head, the motor rating being 82 h.p. The deaerator extraction pumps, of which there are two per set, are made by the same company and each pump is rated for a delivery of 918 gallons per minute, at 220 deg. Fah., with a generated head of 90ft, the pump being driven by a 43 h.p. motor.

The alternators are Richardsons Westgarth machines with a maximum continuous rating of 52·5MW at 0·8 power factor when running at 3000 r.p.m. and generating at 11·8kV, three-phase, 50 c/s. Each generator is solidly connected to an English Electric 60MVA, 11·8/141·5kV step-up transformer giving a reactance of 20 per cent.

A common house service supply is provided from the existing "A" station at 33kV, which is stepped down to 3·3kV by three Metropolitan Vickers 6MVA transformers. For supplying the unit auxiliaries there is, for each generator, a 5MVA, 11/3·3kV transformer made by the same manufacturer. All the remaining auxiliary transformers, ranging from 50kVA, 415/415/240V, for the coal plant lighting to 750kVA, 3·3kV/415V for the coal plant itself, were made by the same company, the aggregate rating of all the auxiliary transformers for three generating sets being 45·45MVA.

As already indicated, the main switchgear is not installed on the station site but at the nearby outdoor substations at Fishergate and Southern Cross. The first two sets in the power station are connected by overhead lines to Fishergate substation and the remaining four sets will be connected to Southern Cross by 132kV oil-filled Pirelli-General underground cable.

All the main switchgear and the principal items of auxiliary switchgear are operated from a control room (Fig. 6), which is equipped with a

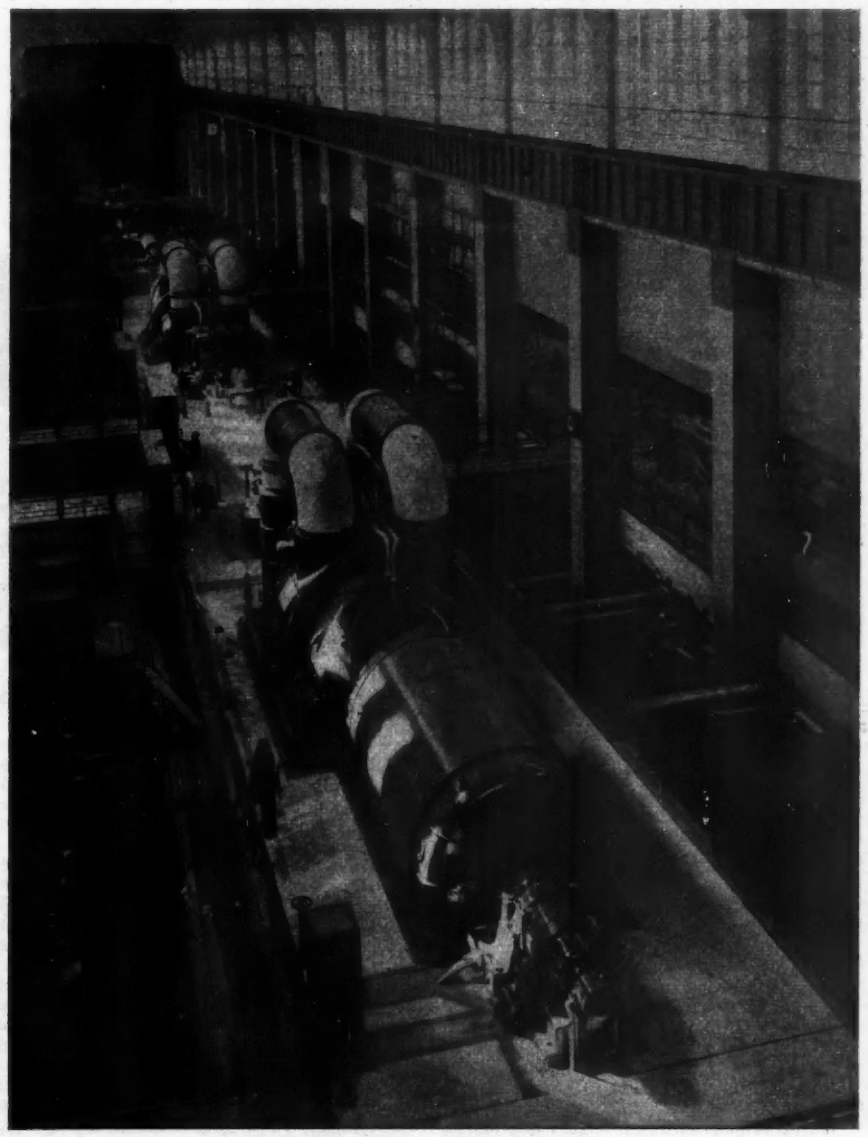


Fig. 5—52·5MW Sets in Turbine Hall

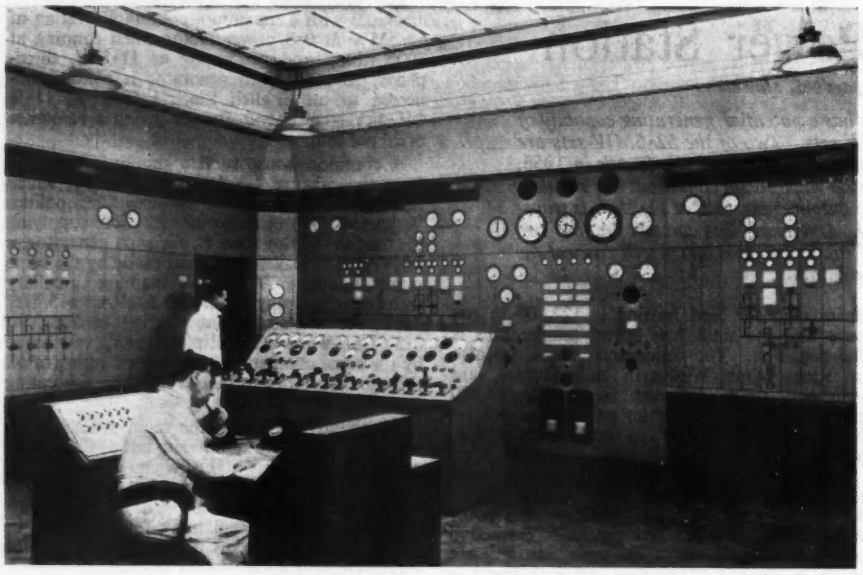


Fig. 6—Main Control Room

miniature control board supplied by Standard Telephones and Cables, Ltd. Some of the 415V switchgear on the coal plant was manufactured by Allen West, Ltd. Apart from this equipment, all the auxiliary switchgear for the first three generating sets is supplied by Metropolitan Vickers Electrical Company, Ltd. The 3·3kV switchgear is metal-clad oil-break equipment of 100MVA rupturing capacity and the 415V equipment consists of air break switchgear and high-rupturing capacity fusegear of 25MVA rupturing capacity.

In conclusion, some figures of the cost and capacity ratios of the power station may be of interest. The estimated final capital cost of the station is £59 per kilowatt. With a turbine room measuring 850ft long by 60ft wide by 81ft 6in high, the generating capacity is 6·5kW per square foot of turbine room floor area. Likewise, the boiler house is 900ft long by 100ft wide by 115ft high and the equivalent generating capacity is 3·7kW per square foot of boiler house floor area. Taking into consideration the main buildings, but excluding the precipitators and administration block, the capacity ratio is 55 cubic feet per kilowatt.

A 170 B.H.P. Mines Locomotive

We have received particulars of a new flameproof diesel mines locomotive of 170 b.h.p., which is only 39in high, recently designed and built by the Hunslet Engine Company, Ltd., Leeds. The makers state that this is the most powerful as well as the lowest diesel mines locomotive yet built; it has been designed specially for the American market where its overall width of 7ft is quite acceptable. It is 18ft long overall and the restricted height has been made possible by fitting a horizontal oil engine.

The new locomotive can be seen in the photograph reproduced on this page. Its frame structure consists of three main steel castings and steel plate sections, welded up into one piece, with the engine and gearbox directly mounted upon it. The whole of the machinery is enclosed in steel casing plates made in sections for easy removal, and giving easy access to all parts for inspection and maintenance purposes. The Cummins six-cylinder engine fitted to the locomotive is designed to give a maximum output of 200 b.h.p. at 2100 r.p.m., but in this installation the fuel injection is set to give up to 170 b.h.p. at 2100 r.p.m.

The six cylinders are in a single bank, and to suit the space available the crankshaft centre line is offset from the locomotive centre line. At the front end the engine is slung from a bridge piece forming one of the locomotive frame stays and at the back its weight is supported by two solid feet.

The engine dry weight is about 2300 lb, or 13½ lb per brake horsepower on the 170 b.h.p. setting; its overall dimensions being 64in long by 55in wide by 23in high.

A Cummins four-stroke engine was fitted to the locomotive for two reasons. First, wide servicing and spare parts facilities for it are offered throughout the U.S.A. so that any replacements or servicing can be given within a few hours. Secondly, of all the horizontal engines considered it showed the best specific fuel consumption and combustion and had an exhaust with the smallest proportion of CO.

All the auxiliaries are belt driven from an auxiliary gearbox driven by a forward extension of the engine shaft. The water and engine oil radiators are of Serck elements with Hunslet headers and are arranged in two groups, one at each side of the forward end of the locomotive, each with its own belt-driven fan. An unusual fitting is an electric heater in the tank to keep the circulating water warm in cold weather with the engine shut down, this heater being connected to an external current supply.

Compressed air for engine starting, brakes, sanding and whistle is supplied by a belt-driven two-cylinder, single-stage Bendix-Westinghouse compressor with a capacity of 12 cubic feet a minute at 90/110 lb pressure. The engine maker's standard practice is to have one large oil-bath intake air filter covering the supply to all six cylinders, but for reasons of space three "Air-Maze" oil-bath filters have been fitted in this locomotive.

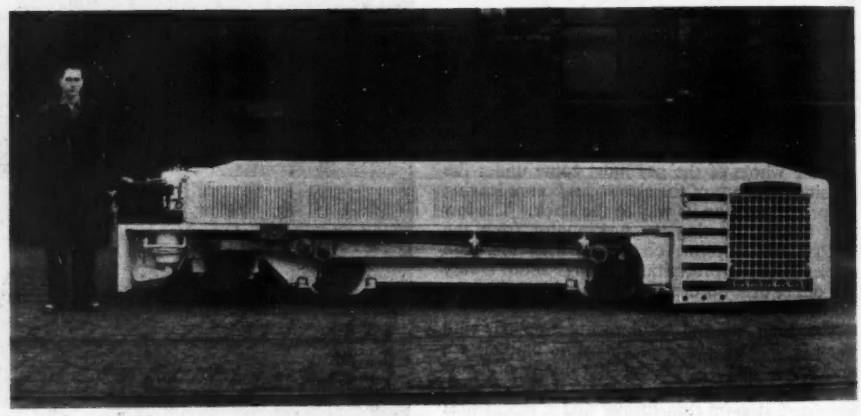
Drive is transmitted through a friction main clutch; a four-speed gearbox with preselective, hand-operated, air-assisted speed changes; a jackshaft carrying the reversing bevels and running on SKF roller bearings, and rod drive to the wheels. The four gear steps give track speeds of 5½, 7, 9½ and 14 m.p.h., with respective tractive efforts of 11,000 lb, 7500 lb, 5700 lb and 3850 lb.

The weight of the locomotive in working order with 30 imperial gallons of fuel in the tanks is 37,000 lb. On the 3ft 6in gauge, curves of 100ft radius can be traversed smoothly. Hand and Westinghouse straight air brakes are included and provision is made for installing the automatic brake for the train.

In order to comply with the safety requirements of the U.S. Bureau of Mines, the engine has a number of additional fittings. The exhaust passes through a conditioner of the makers' jet design with a venturi attachment. This conditioner box, as usual, is of stainless steel, and to eliminate any fire risk it is covered with asbestos and housed in a complete cover sheet of steel. A thermostatically-operated valve blows a whistle if the exhaust gets too hot, and a dial thermometer is fitted so that direct temperature observations can be made. The engine exhaust manifold is water cooled; the exhaust pipe from manifold to conditioner box is water jacketed; and the venturi equipment with auxiliary water tanks provides a water spray into the exhaust stream.

This equipment was not enough to comply with Bureau of Mines requirements. For this reason the air inlet manifolds have adaptors fitted and piped to an automatic vacuum valve, which operates a warning whistle when the vacuum becomes excessive. This fitting was thought desirable in case the flame traps on the inlet side should get choked if cleaning is not carried out as required by the rules. The hand operated throttle is fitted with interconnecting links to a slide valve in the air inlet in such a manner that the slide valves can only be closed when the engine is shut down. Regulations require means to cut off the air supply to the engine to prevent the engine running on methane in a gassy mine when the normal fuel oil supply is closed.

American requirements as to flame-proofing are much the same as those of the Buxton testing station of the British Ministry of Fuel and Power, and stainless steel flame traps are fitted to both intake and exhaust systems. The traps for the exhaust are fitted above the conditioner box and located conveniently for lifting off at the front of the locomotive. Exhaust from the flame traps is mixed with air from the fans and the mixture, baffled in front of the conditioner box before final ejection at the sides, where it is deflected downwards.



170 B.H.P. Mines Locomotive

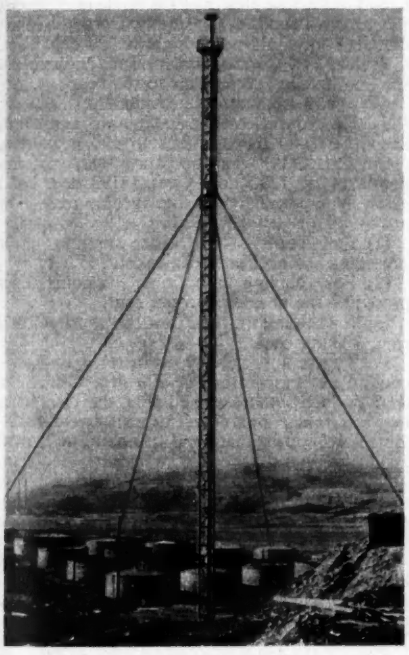
Flare Stacks of Unusual Design

An essential part of the equipment of oil refineries is the flare stack which is necessary for the burning of waste gases from the various process units. For this purpose five flare stacks have been erected at refineries of the Anglo-Iranian Oil Company, Ltd., and supported by 235ft high guyed steel lattice masts. Should the pilot flare, used for igniting the waste gas, fail it can be relighted by a push-button-controlled electrically-operated flame propagation tube.

AN unusual design has been employed for the five flare stacks erected at the three major oil refineries in the United Kingdom of the Anglo-Iranian Oil Company, Ltd., two at the Llandarcy refinery in Wales, one of which we illustrate, one at Grangemouth in Scotland, and two at the Isle of Grain in the Thames estuary. The masts have been designed, supplied and built by the British Insulated Callender's Construction Company, Ltd., together with the electrical equipment, to the specifications of the Anglo-Iranian Oil Company, Ltd.

The 250ft high stacks, 2ft in diameter, used to burn off waste gases from the catalytic cracking plant and other process units, are supported by guyed steel lattice masts 235ft in height. The waste gas is ignited at the top of the stack by a constantly burning pilot flare, but an electrically operated flame propagation unit has been installed to relight the pilot flare in case of failure.

This design of supporting mast—believed to be the first of its kind to be used in the oil industry—was chosen firstly on economic grounds, for it is only two-thirds the steel weight of a comparable self-supporting structure, and secondly because of the difficulty in providing reliable foundations for an unstayed tower on the marshy sites involved. The masts were designed on similar principles to those used for the 750ft television aerial masts erected at each of the four post-war television stations of the British Broadcasting Corporation. The height was governed by the tremendous heat associated with the burning, which eliminates the possibility of working within a range of approximately 350ft, : thus the higher the flare head the



Flare Stack at Llandarcy Refinery

greater the area of ground, in the proximity of the base of the mast, which can be used for refinery buildings.

The cross-sectional area of the stack is based on a maximum rate of flow of waste gas of 1,500,000 cubic feet an hour, and the maximum temperature of the flame, which at maximum discharge might attain a length of 50ft, is estimated at 1000 deg. Fah.

Support Masts

The 235ft mast, weighing 21 tons, is triangular in cross section, with 6ft wide faces, the corner members being two standard angles battened together. The bracing system is by double-warren panels, which are 7ft long, except the two adjacent to the stay attachment point ; these are 5ft long, to ensure equal distribution in the legs of the vertical components of the stay tensions. An external caged ladder, having rest platforms at approximately 60ft intervals, provides access to any part of the mast, at the head of which there is a working platform extending all round the stack.

Three stays, making an angle of 53 deg. with the horizontal, are attached to the corner members of the mast at the 174ft level, with the ground ends secured to concrete anchorages through a length adjusting device, consisting of a crosshead which can slide along two paralell screwed rods. This device is necessary to ensure that the calculated still-air tensions are imposed in the ropes during erection and that inelastic stretch, which may develop due to bedding down of strand wires after they have been in service, can be taken up.

Although it would have been more economical to use two sets of supporting guys, the masts were stayed only at the 174ft level because poor ground conditions at both Grangemouth and the Isle of Grain were likely to cause unequal settlement of the stay anchorages, which, with two sets, would set up damaging strains on the masts unless frequent adjustments were made.

At the mast base a rocker bearing is formed between two steel plates, the lower of which is slightly convex. A 2in diameter steel ball recessed equally and centrally into these plates takes the horizontal shear and the whole bearing is designed to afford free angular movement to the mast. The masts have been designed to withstand a wind velocity of 75 m.p.h., which would cause the mast head to move approximately 2ft 6in from the perpendicular.

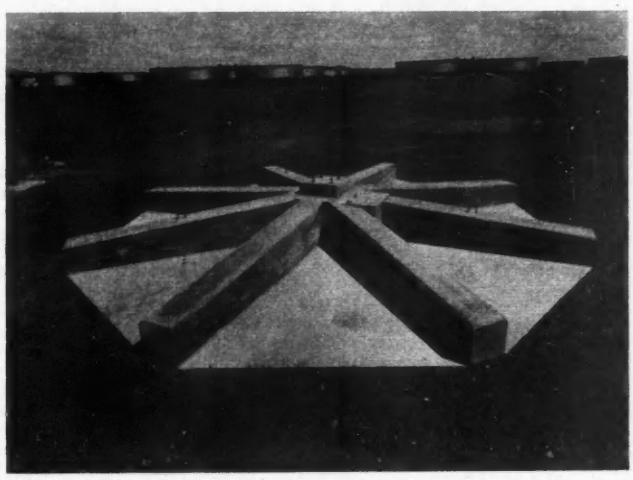
Foundations

The ground conditions at the three sites necessitated three different kinds of foundation. At Llandarcy the ground is firm and, although there is a general slope of 30 deg., conventional foundations were possible for the masts and stay anchorages. However, the orientation of one of the structures would have placed the anchorage of one of the stays in a 30ft depth of newly made ground, and this difficulty was obviated by replacing the one stay with two others which were each attached to a face of the mast. These stays have a horizontally included angle of 120 deg. and are secured to the mast through special frames to allow their lines of action to pass through the centre of area of the mast section and thus avoid the torsional forces which would have arisen had both stays been attached to a single plate on the relevant corner leg of the mast.

At Grangemouth, where piles driven to a depth of 80ft failed to give reasonable bearing values, all the refinery buildings are built on reinforced concrete rafts, so for the mast foundation an octagonal raft was adopted, as shown in the photograph which we reproduce herewith. This is 1ft deep by 30ft across opposite faces, with eight radial stiffening beams, 18in wide, projecting 2ft 6in above the raft at the centre, and tapering to a depth of 1ft 6in. As piles gave reasonable bearing values on the Isle of Grain site, the mast bases each consist of four piles, 45ft long and 12in square, capped with a reinforced concrete head.

Flare Stack

The flare stack is a 2ft diameter mild steel pipe, ¼in thick, made up of 25ft sections welded together after installation, and weighs approximately 11¼ tons. During the erection of the mast the first section of the flare stack, which included an entry for the horizontal run of pipe from the process units, was placed in position and the weight was taken through three adjustable distance pieces inserted under a collar welded to this section of pipe and resting on the supporting frame of the mast. Before entering the vertical stack, the bottom section of which has a removable bolted plate in the underside for maintenance purposes, the horizontal run enters a knockout drum, 8ft in diameter and 16ft long, which traps any liquid carried in suspension by the waste gases.



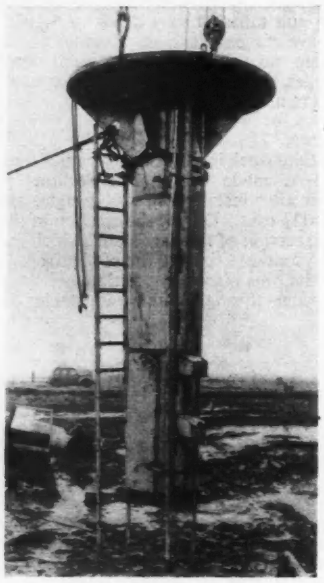
Mast Foundation at Grangemouth

After the mast had been erected the other sections of the flare stack were hauled to the top of the mast and then lowered through the structure. At one end of each section a 4in wide ring, 25in in diameter, was welded to form a short sleeve with an overlap of 2in, into which the bottom edge of the next section was lowered, and when the stack had been installed these were fillet welded to make one continuous pipe.

The stack is located centrally within the mast by horizontal frames spaced 7ft apart and contact is made between stack and frame by three 2in diameter rollers spaced equally round the circumference. The rollers were necessary when the complete stack was raised 4in and the support point taken to the 205ft level. The weight of the stack was finally transferred to the top support point and rested on three adjustable distance pieces, inserted between a collar on the pipe and the mast frame, which were eventually welded into position, at the collar and at the frame, to make a rigid fixture. The stack was suspended at the 205ft level in order to limit its increase in height, due to thermal expansion, to the 45ft above the support point, thermal expansion beneath this point being reflected downwards.

Flange bolted to the top of the stack is a 2ft section of stainless steel-lined pipe, which contains the flame arrester, consisting of layers of stainless steel mesh. Flange bolted to this is the final length of stainless steel pipe, 11ft long,

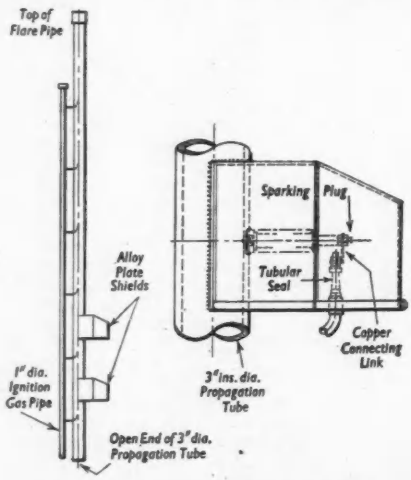
which opens out at the head to a bell mouth 5ft 8in across. This final section, known as the "flare tip," which can be seen in the photograph below, is heavily coated internally with an insulating refractory material. These two sections are bolted, welded in, case they have to be dismantled for maintenance. Subsequent to the completion of the two masts at Llandarcy it was found necessary to inject steam into the flare tip of one of the stacks, through a 4in diameter pipe, to minimise the amount of smoke which was being emitted.



Flare Tip

Ignition System

The waste gases from the catalytic cracking unit and other process plant are fed into the stack and ignited by a constantly burning pilot flame, in the mouth of the flare tip fed from the refinery's fuel gas system through a 1in diameter standard mild steel gas pipe, the top 11ft section of which is of stainless steel. In the event of the pilot flare being extinguished an electrically operated stainless steel flame propagation tube is installed to relight it. This tube is open at both ends and is 11ft long by 3in in diameter, with its top adjacent to the pilot head. It is fed by a 1in diameter pipe from the fuel gas system, the top 11ft of pipe also being stainless steel. The gas enters the propagation tube through slots at a series of levels, and the gas/air mixture is ignited by two independent high-voltage sparking plugs fixed to the tube, protected by special alloy shields and energised from step-up transformers. The arrangement of sparking plug and shield is shown in our line drawing. The operation is push-button controlled from the refinery control room, and the propagation tube remains alight only while the push button is depressed, the same action energising the sparking plugs and working a solenoid-operated valve which starts the flow of gas to the tube.



Propagation Tube and Ignition Plug with Weather Shield

At the base of the mast is a two-way 660V flameproof junction box with a 600V grade two-core V.I.R. lead-covered, steel-wire-armoured and served and compounded cable leading to a compound-filled T service box at the guy attachment point (174ft level). The service box is connected by short lengths of similar cable to the primary terminals of two 440/10,000V transformers.

Each sparking plug, of normal aircraft pattern, is connected to one of the transformers by single-core metal-sheathed mineral-insulated cable, the two plugs thus being on separate circuits. The transformer end of each cable has the metal sheath connected to the other terminal of the secondaries, while the sparking plug end has the sheath bonded to the flame propagation tube by copper strip connected to clamped copper sleeves.

The cable of this high-tension circuit consists of a robust solid-drawn malleable copper tube with the copper conductor embedded within a highly compressed magnesium oxide powder. These materials are inorganic, non-inflammable and non-ageing, and give a cable capable of withstanding considerable mechanical abuse without disturbing the relative position of the conductor.

To reduce the amount of cable which might have to be replaced through damage by the extreme heat, a straight-through junction box is installed midway on each run, between the transformer and sparking plug. Special terminals had to be developed for the cable as ordinary cold seal terminations would break down under the heat. These were made by stripping back the metal sheath and mineral dielectric and passing the bared conductor through a corundite insulator, to which was swaged a copper-plated steel sleeve brazed at one end to the metal sheath of the cable. The conductor was brazed to the inside of a terminal stud on the corundite insulator, which came to within approximately ¼in of the magnesium oxide powder in the cable and the ensuing void was not filled. The two transformers, which are bitumen covered and capable of intermittent operation at 200 deg. Fah. ambient temperature, are installed at the 174ft level as a compromise between the length of h.v. cable required to connect the sparking plugs with the transformers, and the proximity of the transformers themselves to the great heat generated at the flare tip.

Institution of Water Engineers

The fifty-eighth summer general meeting of the Institution of Water Engineers is being held this week at Southend ; the meeting started on Wednesday, May 13th, and the last of the events is taking place to-day. Three technical papers were to be presented during the course of the meeting, which also included, on Wednesday, the installation of the new president and the reading of his presidential address. Visits to the works of the South Essex Waterworks Company, the Hanningfield Water Joint Managing Committee, and the Southend Waterworks Company were also arranged. On Wednesday morning a paper entitled "Water and the Atomic Energy Industry," by A. Wolman, Professor of Sanitary Engineering, Baltimore, and A. E. Gorman, sanitary engineer to the Atomic Energy Commission, was discussed ; on the afternoon of that day the two papers presented were "Management and the Water Industry," by F. H. Bullock ; and "The Formation and Works of the Mid-Northamptonshire Water Board," by L. H. Brown. The new president of the Institution, Mr. William C. Knill, said during the course of his presidential address, that he had endeavoured to foresee some of the activities and problems of the coming years. He made some remarks on the membership (which was 1469 at the end of last year) and the various activities of the Institution, and the various problems of the water industry to which he devoted some remarks included recruitment and training, research, future sources and demands for water, and future planning.

An Experimental Air-Cooled Turbine*

No. II—(*Continued from page 675, May 8th*)

DESIGN AND MANUFACTURE OF THE TURBINE

By J. REEMAN, B.Sc., A.M.I.Mech.E., and R. W. A. BUSWELL, B.Sc.†

This paper was read in two parts; the first dealing with some design aspects of a single-stage experimental high temperature turbine built to enable an experimental investigation to be carried out on the air cooling of nozzles and blades. The turbine was fitted with blades having a large number of cooling passages running the whole length. A description was given of the pressed powder technique used to introduce the small passages in blocks of heat-resisting material from which the blades could be machined. Mention was made of some of the difficulties encountered in manufacture and of the methods of disposal of the cooling air. Cooling characteristic of the blades were discussed in the second part of the paper.

Air Cooling Systems

To give freedom of control, and also to obtain as much information as possible on the quantities of cooling air required to cool various parts of the turbine, arrangement was made for six separate air feeds. Five of these are shown in Fig. 2 opposite and are :—

(1) To the inner inlet header for providing cooling air to (*a*) inlet liner ahead of nozzles, and (*b*) nozzle shroud ring.

(2) To the outer inlet header for providing cooling air to (*a*) nozzles, and (*b*) outer liner ahead of the nozzles.

(3) To the exhaust cooling system.

(4) To the rotor discs cooling system.

(5) To the rotor blade cooling system.

A sixth feed supplies the bearing cooling system and exhaust seal pressurising.

Although metering holes were provided to ascertain the division of the cooling air in the bifurcated cooling systems (1) and (2), control of the division of the cooling air along paths (*a*) or (*b*) was not possible during an actual test. Initial tests, made to ensure that liner temperatures were not exceeded, showed it to be desirable to separate the cooling air feeds to the outer liner and the nozzles. The provision of numerous cooling air ducts to different parts of the turbine added to the complexity of the final rig ; also, as the normal cooling air supply from the plant compressors could be as high as 200 deg. Cent. (392 deg. Fah.), water coolers were necessary in the lines feeding cooling air to the bearings.

Convective cooling was provided for the liners ; the estimated amounts of cooling air required to keep the metal temperatures to 900 deg. Cent. (1652 deg. Fah.) when operating with gas temperatures of 1200 deg. Cent. (2192 deg. Fah.) given as a percentage of the turbine mass flow are :—

(1) For cooling the outer annulus liner preceding the nozzles, 0·8 per cent.

(2) For cooling the inner annulus liner preceding the nozzles, 0·5 per cent.

(3) For cooling the liner over the nozzle shroud ring, 1·0 per cent.

With these approximate estimates, based on a cooling air temperature of 200 deg. Cent. (392 deg. Fah.), it was assumed that the clearances between liners and adjacent walls were maintained at approximately 0·050in. The actual quantities found necessary were 0·5, per cent, 0·7 per cent and 1·5 per cent respectively. This system of convective cooling is not particularly efficient, but at the time it appeared to be the simplest and most convenient to arrange. It should also be emphasised that the method of leaving annular clearances between the ends of the liners, as used in the present design, has little to recommend it apart from ease of assembly. There is insufficient constraint against distortion, and if the distortions were severe it could lead to a maldistribution of the cooling flow over the liners. The larger part of the flow would probably proceed to points round the liner where the clearances were greatest, thus leading to overheating of the liner where clearances were small. For cooling sections of ducting swept by the hot gas stream, such as that at entry to the nozzles,

* The Institution of Mechanical Engineers, May 1st. Abstract.

† Research Laboratories of The General Electric Company, Ltd.

the development of a porous wall liner would probably offer the most efficient and simplest solution. The efficiency of various methods of wall cooling is discussed in a report by Bayley.

The double disc construction was adopted chiefly so that a simple form of blade root could be used, and any blade root cooling air could be isolated from the main blade cooling air. It has the disadvantage that a surface area of 0·27 square feet of the downstream disc rim is scrubbed by the hot gas stream. As the velocity of the gas relative to this surface is approximately 1000ft per second, it was estimated that heat conduction through the disc would not be sufficient to ensure that the disc rim temperature was less than 600 deg. Cent. (1112 deg. Fah.). Provision was therefore made for some cooling air to pass through the rim of the disc and across the blade roots. The cooling passages through the rim of the disc were provided by ninety-nine holes, $\frac{3}{16}$in in diameter, and, on the rear disc, forty-five slots, $\frac{5}{32}$in by 0·045in deep, allowed some of the cooling air to spill out into the hot gas stream at outlet from the blade roots. A provisional estimate of the cooling air flow required to maintain the discs at temperatures well below 600 deg. Cent. (1112 deg. Fah.) was 2 per cent of the main turbine flow, and about a quarter of this quantity would spill out into the gas stream through the slots in the disc. However, at this stage of the art, estimates of air quantities required for disc cooling were little more than intelligent guesses.

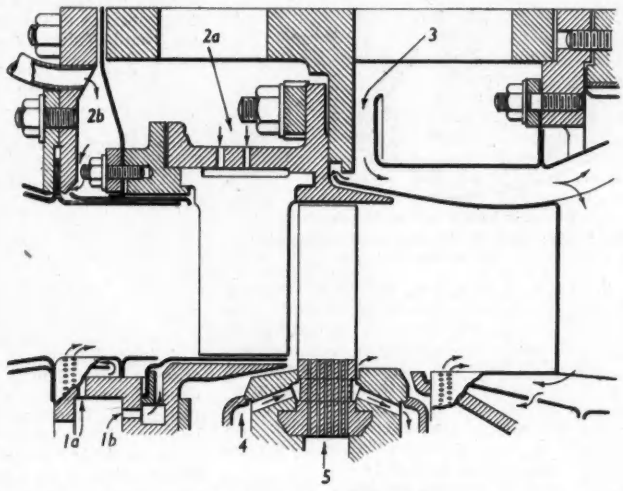


Fig. 2—Air Cooling Systems

Blade and Nozzle Cooling Passages

For blades cooled internally by a number of cooling passages running the whole length of the blade, the equations expressing the mean heat flow to the cooling air, as given by Smith (1948), assume a simple form when heat conduction along the blade is neglected and each cooling passage is assumed to be equally effective.

Thus the expression equating heat flow from the hot gas to the blades and the heat flow from blade to the cooling air is :—

$$S_h\alpha_h(T_g-T_b)=S_c\alpha_c(T_b-T_c)$$

The temperature rise to the cooling air is given by

$$AGc_{pc}dT_c=S_c\alpha_c(T_b-T_c)dl$$

The solution of these equations gives :

$$\frac{(T_g-T_c)_{tip}}{(T_g-T_c)_{root}}=e^{-\frac{S_c\alpha_c}{AGc_{pc}}\cdot l/(1+S_c\alpha_c/S_h\alpha_h)}$$

and

$$(T_g-T_c)=\left(1+\frac{S_h\alpha_h}{S_c\alpha_c}\right)(T_g-T_b)$$

For the set of experimental blades the aim initially was to work with a moderate number of small passages, and to have the flow in the cooling passages turbulent, rather than with a very large number of fine passages. To ensure turbulent flow the minimum Reynolds number at entry to a passage was taken as 4000. Then, with entry cooling air at 200 deg. Cent. (392 deg. Fah.) and 3 atm. pressure, the entry velocity in the cooling passages is 300ft per second for D=0·020in, 200ft per second for D=0·030in, and 150ft per second for D=0·040in. With the maximum cooling air mass flow considered as 0·45 lb per second (2 per cent of the main turbine flow) cooling details for three sizes of cooling passage are then as given in Table III.

With a mean gas temperature relative to the blade of 1150 deg. Cent. (2102 deg. Fah.) the estimated variation in mean metal temperature for the flow conditions stated is shown in Fig. 3.

For the conditions considered, decreasing the diameter of the cooling holes and increasing their number has the following two effects :—

(1) the conductance ratio $\frac{S_c\alpha_c}{S_h\alpha_h}$ is increased.

(2) the factor $\frac{S_c\alpha_c}{AGc_{pc}}\cdot\frac{l}{1+\frac{S_c\alpha_c}{S_h\alpha_h}}$ is increased.

Increasing the conductance ratio $\frac{S_c\alpha_c}{S_h\alpha_h}$ helps to bring the mean metal temperature nearer to the cooling air temperature and so gives better cooling at the root of the blade. An increase in the factor $\frac{S_c\alpha_c}{AGc_{pc}}\cdot\frac{l}{1+\frac{S_c\alpha_c}{S_h\alpha_h}}$ means that the cooling air picks up more heat on its passage through the blade, and the effective cooling of the blade tip is thereby reduced. The combined effects of (1) and (2) are to give better root cooling of the blade without having much effect on the tip cooling. As the root has to carry the greatest stress it is obviously an advantage to have the better root cooling.

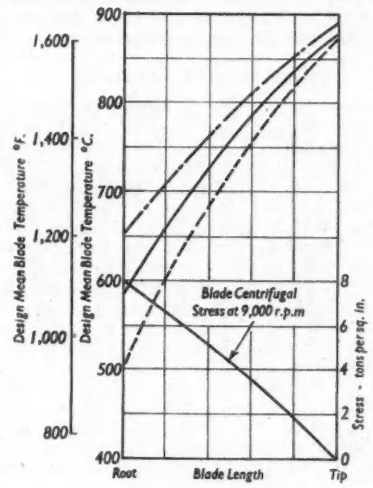
Decreasing the diameter of the holes has, however, two detrimental effects in that the number of holes has to be increased—thus increasing the complexity of the blade—and that the pressure required to force the cooling air through the blades has to be increased. An approximate estimate of the pressure drop required to force the cooling air through the 0·020in diameter holes suggested that the design pressure ratio across the turbine (1/1·38) would be insufficient to give the required cooling flow. The design requirement for the blade was therefore fixed at approximately thirty-three cooling holes, 0·030in in diameter.

For the nozzles the full pressure ratio across the turbine would not normally be available for forcing the cooling air through the cooling passages and a hole diameter even greater than 0·030in was therefore to be preferred. It was estimated that the required cooling could just be achieved for a mass flow of 0·44 lb per second with 0·040in diameter holes. With a cooling air velocity of 150ft per second at inlet to the holes, the required number of holes was estimated at fifty-three. However, with the diameter of the holes fixed, the precise number of holes is not very important, since substantially the same cooling is obtained for the same cooling mass flow, provided the change in number of holes is not too great. This is apparent from the equations expressing the heat flow conditions, as any change in the cooling surface area S_c is compensated by a corresponding increase in the heat transfer rate α_c, so that the total heat transfer $S_c\alpha_c$ per unit blade length is substantially unchanged. For the same mass flow, however, the velocity of the cooling air through the holes is greater the less the number of holes. For design purposes the requirement was taken to be at least forty holes, 0·040in in diameter, per nozzle, with a maximum entry velocity of 200ft per second in the cooling passages (total mass flow of cooling air 0·44 lb per second). Under these conditions the estimated variation in mean temperature along the nozzles is shown in Fig. 4.

Table III—*Blade Cooling Details for a Cooling Passage Entry Reynolds Number of* 4000

Hole diameter, inches... ...	0·020	0·030	0·040
Cooling air velocity at inlet, feet per second	300	200	150
Number of cooling passages	50	33	25
S_c per inch of blade, square feet	0·0218	0·0216	0·0218
Mass flow AG per blade, pound per second	0·00455	0·00455	0·00455
$S_c\alpha_c$	2·26	1·51	1·13
$S_h\alpha_h$			
$\frac{lS_c\alpha_c}{AGc_{pc}}/1+\frac{S_c\alpha_c}{S_h\alpha_h}$	0·862	0·749	0·662

α_h=0·032 B.Th.U. per second per square foot per deg. Fah.
S_h=0·0174 square feet per inch of blade.

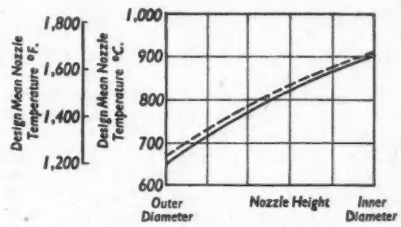


——— 25 holes, 0·040in diameter.
——— 33 holes, 0·030in diameter.
— — — 50 holes, 0·020in diameter.

Gas temperature relative to blade 1150 deg. Cent. (2102 deg. Fah.)
Cooling air temperature 200 deg. Cent. (392 deg. Fah.)

Fig. 3—Estimated Variation of Mean Blade Temperature

For the nozzles the full pressure ratio across the turbine would not normally be available for forcing the cooling air through the cooling passages and a hole diameter even greater than 0·030in was therefore to be preferred. It was estimated that the required cooling could just be achieved for a mass flow of 0·44 lb per second with 0·040in diameter holes. With a cooling air velocity of 150ft per second at inlet to the holes, the required number of holes was estimated at fifty-three. However, with the diameter of the holes fixed, the precise number of holes is not very important, since substantially the same cooling is obtained for the same cooling mass flow,



Cooling mass flow 2 per cent of main turbine flow.
— — — — 40 holes, 0·040in. diameter.
——— 53 holes, 0·040in. diameter.

Gas temperature 1200 deg. Cent. (2192 deg. Fah.), cooling air temperature 200 deg. Cent. (392 deg. Fah.)

Fig. 4—Estimated Variation of Mean Nozzle Temperature

Although a fair estimate can be made of the size and number of cooling passages for a certain lengthwise distribution of temperature, the disposition of the holes for a uniform chordwise distribution appears to be almost impossible to

Notation.

A—Total cross-sectional area of cooling passages, square foot
c_{pc}—Specific heat of the cooling air, B.Th.U. per lb per deg. Fah.
D—Diameter of the cooling passage, inches
G—Weight velocity of cooling air, lb per sec. per square foot
l—Length of the blade, inches
S_c—Cooling surface area (square foot) per inch of blade height
S_h—Exposed surface area (square foot) on the hot gas side per inch of blade height
T_b—Blade metal temperature, deg. Fah.
T_c—Cooling air temperature, deg. Fah.
T_g—Hot gas temperature, deg. Fah.
α_c—Heat transfer coefficient on the cold gas side, B.Th.U. per second per square foot per deg. Fah.
α_h—Heat transfer coefficient on the hot gas side, B.Th.U. per second per square foot per deg. Fah.

achieve on conventional sections. For uniform heat transfer to the hot blade surface the hole distribution should be such that the available cooling surface for each portion of external blade surface is the same over the whole of the blade. Actually, as the heat transfer on the hot gas side is greater towards the nose of the blade, a concentration of holes above the average is required in the leading edge region. For the conventional nozzle and blade sections taken in the design, and shown in Fig. 5, it is difficult to get the required concentration of cooling holes in the leading edge. In the trailing edge it is not even possible, with the holes sizes considered, to provide anything like the cooling surface required. The disposition considered in design as being capable of achievement without too great an elaboration in technique is given in Fig. 5. It is apparent that the hole disposition is largely determined by the geometry of the sections and the provision of even a small number of holes in a thin trailing edge presents the greatest difficulties.

Disposal of Cooling Air

Before dealing with the method of blade construction in more detail, mention should be made of the need for careful consideration of methods for the best disposal of the cooling air with this type of cooling. If large tip clearances have to be used, end leakage losses may well be appreciable. With the present design the losses arising from the end clearance between the nozzles and shroud could probably be avoided by completely enclosing the nozzle tips in a hollow shroud and then suitably directing the cooling air into the gas stream. Also, with the blades, as much use as possible needs to be made of the kinetic energy in the cooling air discharge, but to do this would call for a considerable refinement in the tip of the blade. For the assumed design conditions the estimated work done on the 2 per cent of cooling air passing through the blades represents approximately 1·5 per cent of the turbine output.

Manufacture of Cooled Nozzles and Blades

Preliminary Investigations.—The design requirement demanding cooling passages at least equivalent to forty holes, 0·040in in diameter, although not excessive from the cooling aspect, called for a considerable refinement in the formation of cooling passages achieved in fabricated air-cooled blades. Development of the fabricated blade to give such cooling passages did not appear a particularly attractive proposition, so that other methods of providing the cooling passages were examined. Drilling holes of the length/diameter ratio called for was, of course, out of the question. Thus, in view of some work which had been done on the preparation of sintered alloys for high-temperature service, attention was paid to the possibility of pressing a core material in the sintered compact which could be removed by heat-treatment at a temperature well below the sintering temperature of the pressed compact. The essential requirement of the core material was that it should not interfere with the normal sintering operation of the alloy ; further desirable features were that it should be readily available and easily worked into a wire form of any diameter.

With this method of introducing the cooling passages the sequence of operations in the manufacture of the cooled nozzle or blade became :—

(1) Preparation of alloy constituents in powder form with the correct particle size and condition.

(2) Pressing of the powder in a die of suitable shape under a final pressure of about 35 tons per square inch. The powder compact to be built up progressively in layers, core wires being introduced at the appropriate stages in the required positions.

(3) Heat-treatment of the compact to remove the core material.

(4) Sintering of the compact at a temperature of 1325 deg. Cent. (2417 deg. Fah.) in a reducing atmosphere to obtain the final metallic alloy. During this process of consolidation considerable skrinkage takes place—approximately 10 per cent on the linear dimensions of the pressed compact.

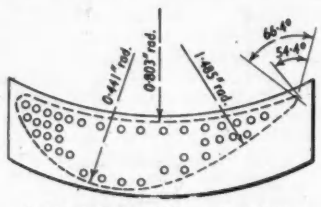
(5) Machining of the sintered block to shape and to the required accurate dimensions.

This method of manufacture introduced several problems, such as :—

(*a*) Obtaining satisfactory high temperature strength properties of a sintered alloy.

(*b*) The production of distortion-free blocks from which the blades and nozzles could be machined.

Difficulties arising from (*a*) fall into the metallurgical field, and it is not proposed to discuss these in this paper. Since a certain amount of work had been done on the preparation of a cobalt-base alloy of the Vitallium type (containing



1in chord ; holes 0·030in nominal diameter.

Fig. 5—Blade Profile Showing Possible Disposition of Cooling Holes

30 per cent of chromium and 6 per cent of tungsten) by powder metallurgy methods, this alloy was used for the cooled nozzles and blades.

Some Properties of the Sintered Vitallium Type of Alloy.—Normally the properties of a sintered product are much inferior to those of the equivalent cast or wrought material because of the inherent porosity of the sintered material. To minimise this porosity several methods have been employed in the past, such as :—

(1) Forging the sintered product.

(2) Infiltrating the sintered body with a metal of lower melting point.

(3) Incorporating in the original metal powder a suitable alloying element which becomes molten during the sintering process (liquid phase sintering).

(4) The application of pressure during sintering (hot pressing).

The introduction of holes for cooling passages in the compact precluded the use of any of these normal methods for enhancing the mechanical properties of the sintered material. It was therefore necessary to obtain a final sintered product with virtually no porosity. Work on a Vitallium type of alloy, described by Buswell, Pitkin and Jenkins (1951), had shown that this could be done, provided that there was rigid control of the particle size and purity of the powder mixes, and that the sintering was carried out under con-

Table IV—*Properties of Sintered Vitallium Type of Alloy*

Nominal composition	64 per cent Co, 30 per cent Cr, 6 per cent W		
Density, gm. per cu. cm.	8·44 (theoretical 8·54)		
Mean thermal expansion :—			
70–1000 deg. F., in per in per deg. F. × 10⁶	7·95		
70–1200 deg. F., in per in per deg. F. × 10⁶	8·45		
70–1500 deg. F., in per in per deg. F. × 10⁶	9·08		
70–1600 deg. F., in per in per deg. F. × 10⁶	9·27		
70–1800 deg. F., in per in per deg. F. × 10⁶	9·95		
1500 deg. F., in per in per deg. F. × 10⁶	9·86		
1800 deg. F., in per in per deg. F. × 10⁶	11·65		
Thermal conductivity (B.Th.U. per sq. ft. per ft. per sec. per deg. F. × 10⁴)	Approximately 4·0 at 750 deg. C. (1382 deg. F.)		
Hardness (V.P.N.–30 kg.)	340–350		
Izod impact value, ft-lb	8		
	R.T.	750 deg. C.	850 deg. C.
Ultimate tensile strength, tons per sq in ...	44·5	34·5	21
Yield strength, tons per sq in	35·5	22·5	15
Elongation, per cent on 0·625in	6·1	7·5	10·5
Young's modulus (lb per sq in × 10–⁶)		18·0	
Stress for fatigue fracture in 300 hours (Haigh machine), tons per sq in		0 ±10·5	0 ±6·5
Stress to fracture under steady load :—			
In 10 hours, tons per sq in		17·5	
In 100 hours, tons per sq in		12·5	
In 1000 hours, tons per sq in		7·5	

trolled conditions in an atmosphere of dry purified hydrogen. A fairly high "compacting" pressure was required, approximately 30–35 tons per square inch, and there was little advantage to be gained by increasing this. With this final compacting pressure the sintering time required was approximately eight hours at 1325 deg. Cent. (2417 deg. Fah.). The sintering time was not critical ; it depended on the sintering temperature and with 1325 deg. Cent. (2417 deg. Fah.) a low porosity was attained after five hours. However, the standard time of eight hours was selected to allow sufficient time for diffusion and the attainment of a homogeneous alloy.

The sintered material thus produced was virtually carbon-free and, although the fatigue properties at 750 deg. Cent. (1382 deg. Fah.) were encouraging, the creep strength at this temperature was lower than that of the best high-temperature materials now available. Some of the properties of this type of sintered Vitallium are given in Tables IV and V.

Table V—*Creep Properties of Sintered Vitallium Type of Alloy*

Temperature, deg. Cent.	Stress, tons per sq in	Time (hours) for specific percentage creep strain				Time for fracture, hours	Elongation on 1in, per cent
		0·5	1·0	2·0	3·0		
750	12	—	—	30	47	125	16
	10	—	32	80	140	320	10
	8	25	70	195	340	870	10
	6	55	190	570	1110	2050	8
850	4	18	50	95	130	195	9

A high density was achieved in spite of the absence of a liquid phase and with further development of sintered alloys, either cobalt or nickel base, there was no reason to believe that substantial improvement on the creep properties given in Table V could not be obtained. However, rather than await further metallurgical developments, the properties given in Table V were accepted as being adequate for the initial investigation into the effectiveness of air cooling on the form of blade and nozzle considered, that is, with multiple internal cooling passages.

Core Material.—Because low porosity in the final sintered product was essential, a careful choice had to be made of the core material. Organic core materials of the type often used in ceramic work were not suitable with Vitallium type of alloy because of the contamination they produced, and it appeared to be desirable to have a core material which could be completely removed prior to the final sintering of the compact. Cadmium with its low melting and boiling points (320 deg. Cent. (608 deg. Fah.) and 767 deg. Cent. (1413 deg. Fah.) respectively) appeared to possess the desired properties, and this was confirmed by initial tests which showed that it could easily be evaporated from the pressed compact even at normal atmospheric pressures.

When a matrix of wires was introduced it was found to be necessary to adhere to a given heating cycle in the process of the cadmium removal to avoid too rapid vaporisation of the cadmium ; if the cadmium was removed too quickly cracking was liable to occur between the holes and from the holes to the outside surface of the compact.

Form of Nozzle and Blade Compacts.—With a pressed powder compact of the Vitallium type of alloy the shrinkage which takes place on sintering is approximately 10 per cent on linear dimensions, when the final compacting pressure is 35 tons per square inch. Although the fundamental mechanism of the sintering process is not fully understood, the shrinkage is dependent to some extent on the compacting pressure. If, therefore, the compacting pressure is not uniform, serious distortion troubles arise owing to the non-uniformity of the shrinkage throughout the compact. With the blades and nozzles envisaged only a small amount of distortion could be tolerated, as the presence of cooling passages precluded much being done in the way of hot pressing, either during or after sintering. Largely because of this, attempts to press the blades and nozzles approximately to shape soon had to be abandoned, as uniformity of compacting pressure was difficult to achieve for such sections with their comparatively thin trailing edges.

The more uniform the thickness of the section the more uniform the pressure, and the early form of pressed compact envisaged is shown by the contour in Fig. 5, where the concave side of the blade is roughly to shape and the compact of constant thickness. Tests made on a number of solid bars, however, showed that distortion still occurred ; there was an opening-out of the concave face and a lengthwise bowing. Although

allowance could have been made in the die and punch design to take account of the change in curvature of the concave face, the longitudinal distortion presented difficulties. Longitudinal bowing was subsequently experienced on rectangular blocks and was found to be due to the lack of flatness of the surface on which the block rested during sintering.

Preparation of Rectangular Compacts with Cooling Passages.—With blocks of rectangular section it was found that a compact could be satisfactorily built up in layers provided that the compact was subjected to only a light pressing after the addition of each layer of powder. The method ultimately employed was to use a serrated punch of the type shown in Fig. 6 for giving the light pressing after the addition of each powder layer. The prepressed surface of each layer had then a series of ridges and troughs suitably positioned, and to provide for a hole at a given distance from the edge of the compact it was only necessary, in theory, to insert a wire in the appropriate trough. Thus these troughs located the horizontal position of the holes, the vertical position being located by the weight of powder added for each particular layer. The pitching of the punch serrations was therefore instrumental in fixing the pitching of the holes. Although it was not practicable, because of the need to have well-defined troughs, to have a pitch much less than two to three wire diameters, a close vertical spacing could be achieved by the use of two punches used alternately, with the serration displaced relatively by half a pitch.

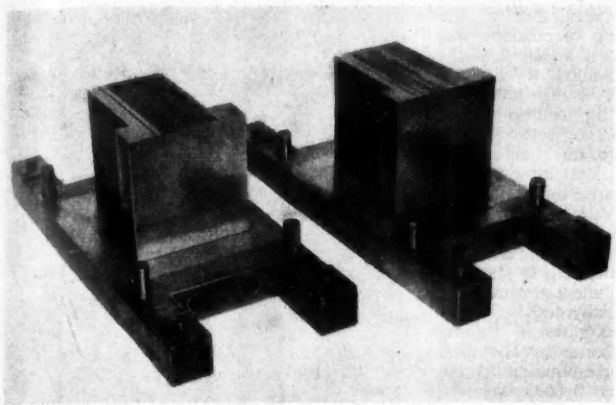


Fig. 6—Prepressing Punches for Nozzle Block Formation

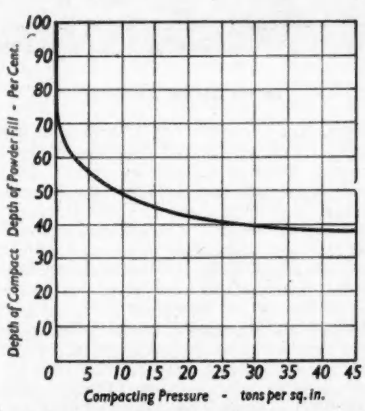


Fig. 7—Variation of Powder Thickness with Compacting Pressure

After building up the main body of the block by this process of precompacted layers a further build-up over the root portion could be made when this was desired, as in the nozzle blocks. For this purpose a suitable metal filler piece was inserted in the die over the rest of the compact. With the precompacting completed the final compact was pressed to a pressure of 30–35 tons per square inch, and only after the final pressure had been applied could the compact be removed from the die. With this laboratory scale arrangement the time taken to produce a fully compacted block with forty core wires was 1½–2 man-hours.

The extensive powder movement which takes place on pressing the compact is probably one of the chief obstacles to be overcome in order to obtain an accurate disposition of the cooling holes. With a rectangular block the variation in powder thickness with compacting pressure is shown in Fig. 7 for a particular batch of powder. The actual movement is dependent on the particle size distribution in the powders, but the curve shown in Fig. 7 is typical for the powders used. In the initial stages of compaction a large movement takes place which is not uniform throughout the section and, for accurate positioning of the holes it would obviously be an advantage to be able to insert the wires after an appreciable amount of compacting has taken place. A high precompacting pressure, however, led to uncertainty of the bonding between the layers and on this account the precompacting pressure had to be limited to about 2–3 tons per square inch.

Because of the low precompacting pressure the flow of powder during the final pressing to 35 tons per square inch was still appreciable. Further, it was not uniform, even with a block of rectangular section with no root build-up because of frictional effects on the boundary walls of the die. As a result of this non-uniformity in powder flow there was a certain lengthwise distortion of the hole position and a departure from the design crosswise distribution.

Machining of Blades and Nozzles.—As the ends of the blocks were to be discarded in the subsequent machining operations, the lengthwise distortion of the hole position was not serious, but the wall frictional effect on the crosswise distribution made difficult the assessment of the hole positioning for jigging purposes. Before the blocks could be machined, therefore, it became necessary to determine the average position of the holes experimentally from measurements made on a number of sectioned blocks. To do this two of the surfaces at right angles were subjected to a given grind and the hole positions determined with reference to these datum planes.

Measurements showed that, on each block, the wander of any one hole was less than 0·006in along the length of the nozzle. However, with the mean hole position defined by the average of the whole set of readings taken from a number of blocks, the overall deviation of the hole position was greater than this. It was found that the transverse positioning of the holes was not quite so consistent from block to block as that of the vertical positioning.

In addition, there were slight variations in block width and on this account the total horizontal deviation from the mean position was rather greater for the hole farthest away from the datum surface than for the one closest to that surface. As the trailing edge hole was the one where accurate positioning was most essential, the two datum surfaces provided for machining were taken to be those closest to the trailing edge hole. Further, as a precautionary measure, to try to avoid having holes break surface in the subsequent machining, nozzle blocks with widths outside certain limits were rejected. The number of rejects on this account was quite small and, of some fifty blocks machined, a surface break through a hole occurred only on two blocks. The holes are slightly elliptical as the result of deformation of the cadmium during pressing; the hydraulic mean diameter is, however, approximately 0·040in.

The determination of the hole positioning in the blade blocks was carried out in a similar

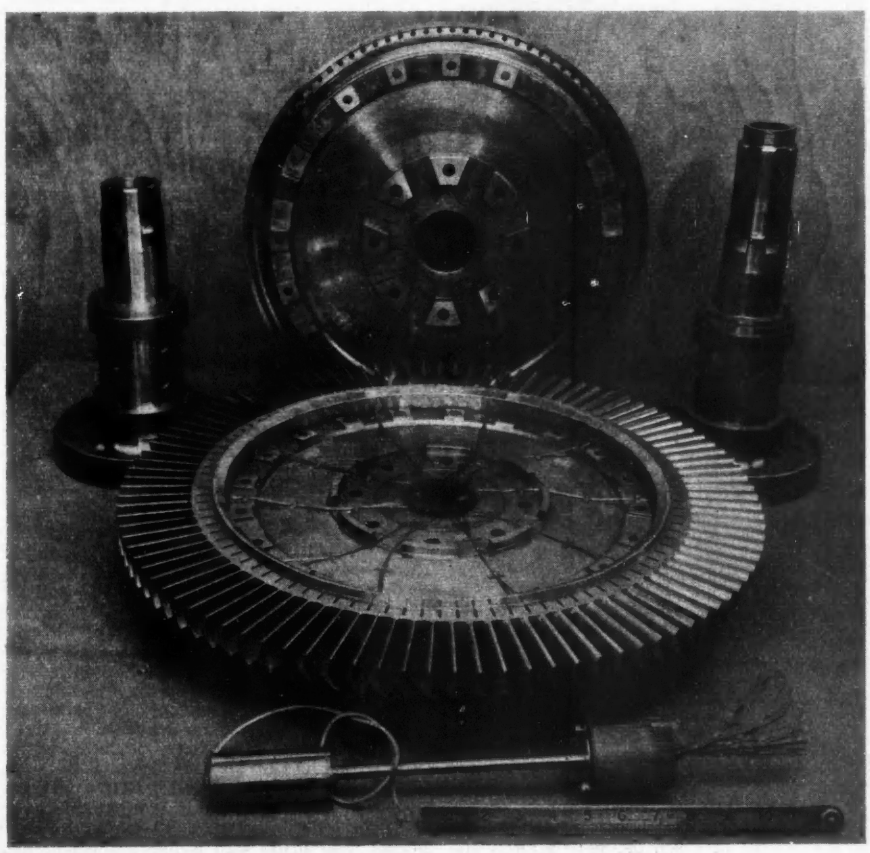


Fig. 8—Final Installation of Rotor with Thermocouples

manner to that for the nozzle blocks. On several blocks the leading edge hole was lost and on others it ran unpleasantly close to the blade surface. Fig. 9 shows the completed blade.

For positioning of the holes relative to the blade profile it would have been more convenient to have had one face of the block pressed to shape and forming either the concave or convex face of the blade. This face would then have been taken as the datum face for positioning of the holes and a rather better disposition of holes, as shown in Fig. 5, would probably have been achieved.

For purposes of temperature measurement a

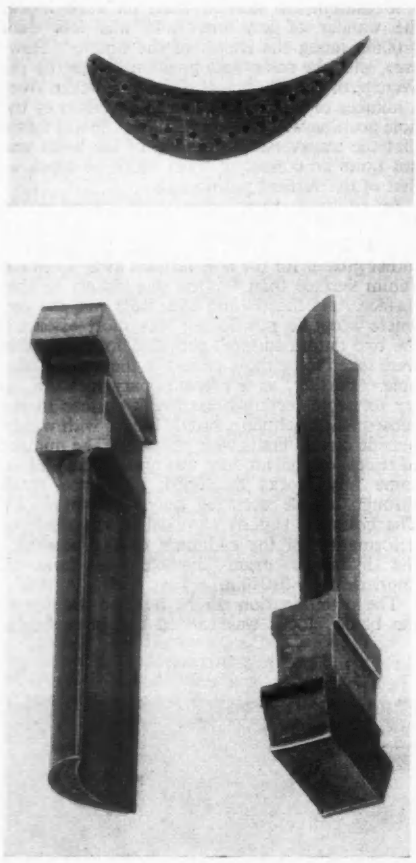


Fig. 9—Completed Blade

number of special nozzles and blades were made in which larger blind holes were provided for small thermo-couples. Two of these larger holes, one in the leading edge and one in the trailing edge, were inserted at the expense of two of the cooling holes, and one was provided in the centre of the profile.

The turbine rotor (Fig. 8) was fitted with ten special blades; on three blades the thermo-couple holes extended a distance of $\frac{1}{4}$in outwards from the root, on four others to the mid-height, and on the remaining three to within $\frac{1}{4}$in of the blade tip. The holes provided were, however, only 0·040in by 0·030in and because of the small hole size some small-diameter thermo-couples had to be developed.

Conclusions

Although the high-temperature strength of the sintered Vitallium type of alloy. used for the nozzles and blades does not approach that of existing blade materials, it was considered that the form of nozzles and blades would enable valuable information to be obtained on the effectiveness of air cooling. The measurement of blade temperatures on these cooled blades would be a step towards filling the gap which at present exists between stationary rig tests and the ultimate cooled turbine. Further refinements in cooled blades can be made, but, as already mentioned, greater attention is probably necessary to the manner in which the cooling air is discharged from the nozzles and blades in order to minimise losses on this account.

American Engineering News

(By Our American Correspondent)

The Impact Resistance of Concrete

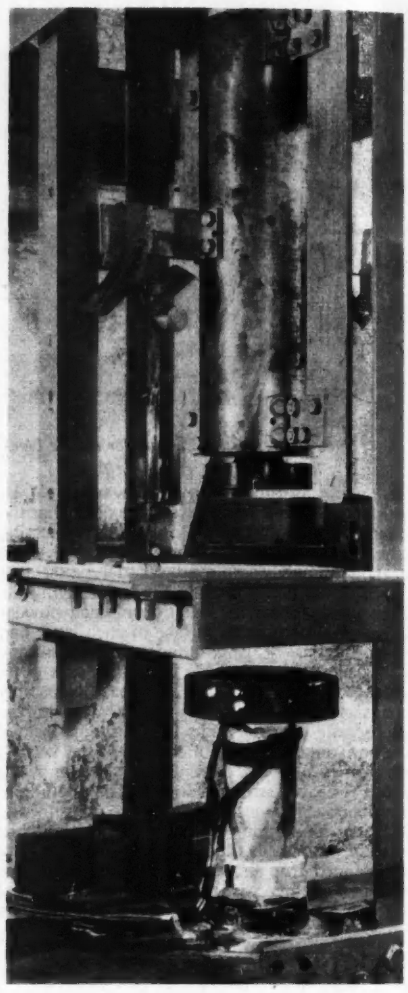
While considerable data have been collected on the strength of various types of concrete under static conditions, relatively little is known about their resistance to impact. To obtain quantitative data in this field, the National Bureau of Standards is at present conducting an extensive study of the properties of concrete under impact in co-operation with the Bureau of Yards and Docks of the U.S. Department of the Navy. In results obtained thus far, the dynamic compressive strength of concrete was found to be up to 84 per cent higher than the static strength and the modulus of elasticity up to 47 per cent greater. Although until now most work on the effect of the loading rate on the elastic properties of plain concrete has been confined to rates of straining of less than 2×10^{-3} inch per inch per second, the current work at the N.B.S. Structural Engineering Laboratory is covering a range of the rate of straining of concrete from 10^{-6} to 10in per inch per second.

In the investigation at the Bureau 3in diameter by 6in long cylinders were subjected to standard static tests in a 60,000 lb hydraulic testing machine and to impact tests in a specially designed drop-hammer machine at various rates of loading up to 10in per inch per second. The total duration of the impact corresponding to the latter rate of loading was 0·0003 seconds. "Softer" impact tests having a duration of about 1 second were made in a hydraulic machine running at full speed. Two kinds of concrete were used: a "weak" concrete having a nominal static compressive strength of 2500 lb per square inch and a "strong" concrete having a nominal static compressive strength of 6500 lb per square inch.

The drop-hammer machine, which is shown in the accompanying illustration, consisted essentially of a 3200 lb steel anvil for supporting the test specimen, a 140 lb drop-hammer and a device for catching the hammer on the rebound. The hammer tip, which made contact with the test specimen, had a flat surface. Four compression springs supported the anvil, which was limited in its travel by four shock absorbers and two rubber buffers between the bottom of the anvil and the concrete base of the machine. The anvil was constrained against motion in a vertical plane by means of two hinged sway plates, one at each end of the anvil, which were anchored to the concrete wall at the rear of the machine. The maximum height of drop was 5ft 6in and the maximum velocity of the hammer was about 19ft per second. Various designs of rubber buffers were placed on top of the capping plate of the specimen to control the duration of impact.

Forces were measured by four bonded-wire strain gauges arranged around the periphery of a cylindrical dynamometer. The gauges were attached to the dynamometers with nitro-cellulose cement and dried in air several hours before curing in an oven at a temperature of 60 deg. Cent. Upon removal from the oven, the gauges were coated with hot cerese wax to protect the nitro-cellulose cement from the effects of atmospheric moisture. Similar gauges on the concrete test specimens provided the strain measurements. The outputs of the bonded-wire strain gauges on both the dynamometer and the specimen were fed into a dual-channel cathode-ray oscilloscope. The single-sweep trigger which initiated the driven sweep of the oscilloscope delivered an external synchronising pulse in response to the closure of a pair of external contacts by the drop-hammer. The duration of impact obtainable on the drop-hammer machine ranged from 0·004 seconds to 0·0003 seconds. The oscilloscope data were recorded on 35mm film with a fixed-focus camera having an f/3·5 lens. The time base was provided by an audio-frequency oscillator, which modulated the intensity of the beams so that the beam traces became dotted lines; the modulating frequency was varied from 5000 c/s to 20,000 c/s, depending on the duration of the test. In the "softer" impact tests the measurements were made with a four-channel carrier bridge and recording oscillograph.

The dynamic compressive strength of a given type of concrete was found to be higher than the static compressive strength, becoming relatively greater as the duration of impact decreased. The ratio of the dynamic to static strength for the "weak" concrete ranged from 1·09 for a 0·9 second impact to 1·84 for a 0·00025 second impact. The corresponding ratio for the "strong" concretes ranged from 1·13 for the longer impact to 1·85 for a 0·00043 second impact. The modulus of elasticity of the concrete was affected in a manner similar to the



Impact Testing Machine

strength, i.e. the ratio of dynamic to static modulus increased as the duration of impact decreased, reaching a maximum of 1·47 for the "weak" concrete and 1·33 for the "strong" concrete. The linear portions of the stress-strain curves became longer and steeper as the duration of impact was decreased. The ratio of strain energy absorbed under dynamic loading to that absorbed under static loading reached a maximum of about 2·2 for both concretes tested. The significant increases in compressive strength, elastic moduli and ability to absorb strain energy under impact loading are considered to be of importance to the designer. Further studies of the effect of impact on concrete in flexure are now in progress and, when completed, are expected to enable the designer to take account of the potential saving of material in structures to be erected where they may be subjected to earthquakes, to bomb blasts, or to similar impact loading.

Conveyor Belting.—A combined catalogue and handbook of conveyor and elevator belting has just been published by the Dominion Rubber Company, Ltd., 62/64, Horseferry Road, London, S.W.1. This book, in addition to giving particulars of the materials, construction and applications of the various types of belting made by the company, includes useful data for designers of equipment and users of belting.

Industrial and Labour Notes

Wages and Hours

Among the matters discussed last week at the annual conference of the Amalgamated Engineering Union's national committee was the wages claim which is being recommended by the Confederation of Shipbuilding and Engineering Unions. A resolution supporting the claim for a 15 per cent increase in wages was carried unanimously. The final decision as to proceeding with the claim is to be taken by the Confederation of Shipbuilding and Engineering Unions next week. During the discussion by the A.E.U. national committee, the president, Mr. J. Tanner, said that the claim would be based on increased productivity, increased cost of living, increased profits, and the importance of the engineering industries to the country's economy.

Earlier in the committee's deliberations a resolution was carried instructing the executive of the A.E.U. to press for the introduction of a forty-hour week, without loss of pay, instead of the forty-four-hour week at present worked. Mr. R. G. Crane, who moved this resolution, urged that the forty-hour week was necessary to minimise recent unemployment, and that it was desirable also because of the rights of the workers to more leisure time. The seconder of the resolution claimed that when the working week had been shortened production had invariably gone up.

Britain's Overseas Trade

In the course of a speech which he made at Llandrindod Wells last Friday evening, the President of the Board of Trade, Mr. Peter Thorneycroft, gave the provisional trade figures for April. He said that exports of United Kingdom goods had been valued at £214,800,000, compared with a monthly average of £208,500,000 in the first quarter of the year. That increase, Mr. Thorneycroft added, had been achieved despite the fact that April contained only twenty-four working days, compared with an average of nearly twenty-six in the first quarter. Imports during April had been valued provisionally at £293,400,000, compared with £272,400,000 a month in the first quarter, and with a monthly average last year of £290,100,000. Re-exports in April reached a value of £9,000,000, compared with £10,000,000 a month during the first quarter, and the excess of imports over total exports was therefore nearly £70,000,000. In the first four months of this year, Mr. Thorneycroft said, the excess of imports over exports had averaged about £58,000,000 a month, which figure should be compared with a monthly average of £63,000,000 over the whole of 1952.

Employment and Unemployment

The Ministry of Labour's latest report on the employment situation in Great Britain states that during March the total working population declined by 22,000 to 23,254,000 (15,851,000 men and 7,403,000 women). The strength of H.M. Forces decreased by 2000 to a total of 871,000, and at the end of the month the number of people in civil employment was 22,027,000 (14,776,000 men and 7,251,000 women), which was 12,000 more than at the end of February.

During March the labour forces of the basic industries increased by 5000, bringing the total to 4,027,000. The only addition, however, occurred in employment in agriculture and fishing, the returns of the other basic industries all showing slight reductions in manpower. The number of wage-earners on colliery books at the end of Marcn was 720,000, or 1000 less than in the preceding month, and in transport and communication there was a decline of 3000, making the total 1,719,000 at the end of the month. In the manufacturing industries there was a net decline of 8000 in the total labour forces, the figure for the end of March being 8,686,000. There were small additions to the numbers employed in the chemicals, textile and clothing trades, but there was a drop of 9000 in the manufacturing group classified by the Ministry as "engineering, metal goods and precision instruments," the figure for that group at the end of March being 2,540,000, compared with 2,558,000 at the end of last year. In other industries and services the biggest change during March was in building and contracting, which added 14,000 to its labour force and brought the total employed to 1,426,000.

Unemployment returns made on April 13th show that there were then 375,806 people registered as out of work, compared with 397,038 registered on March 16th. The Ministry says that the April 13th figure represented 1·8 per cent of the total number of employees. It included 29,570 who were described as being temporarily stopped.

Censuses of Production and Distribution

It was stated in the House of Commons last week that the President of the Board of Trade had appointed a committee to advise and make recommendations about future policy concerning the taking of censuses of production and distribution. Both sides of industry are represented on the committee, the chairman of which is Mr. W. R. Verdon Smith, joint managing director of the Bristol Aeroplane Company, Ltd.

The first census of production was taken in this country in 1907, and further censuses have been taken at intervals since then. Since 1948 five censuses of production have been taken, and the first census of distribution and other services was made in respect of the year 1950. It is felt that sufficient experience has been gained to enable this newly appointed committee to consider the future organisation of censuses so as to secure all the necessary information, to enlist the support of industry generally, and to promote an economical organisation of the work involved. The Board of Trade has made it quite clear, however, that this new committee is distinct from the advisory committees on the censuses of production and distribution which are set up under the Statistics of Trade Act.

The Coal Board's Recruitment Policy

The National Coal Board is circulating to all grades of management within the coal mining industry a leaflet setting out its policy concerning the recruitment and training of youth. The Board emphasises that it is anxious to recruit most of its future workers as boys under eighteen, to train them, to create within them confidence in and respect for management, and to give them a sense of attachment to the industry. These the Board declares to be permanent objectives, uninfluenced by the manpower situation at any particular time.

The aims of the Board's youth policy are to ensure that boys who are going to be manual workers receive proper training and experience ; that boys who are going to be tradesmen, supervisors, engineers or managers are encouraged and helped to develop their abilities to the full ; that boys away from home are well looked after ; and that the public, youth employment officers and parents of boys leaving school are convinced that coal mining offers a worthwhile career. In its leaflet, the Board says that giving boys the right kind of work is the most important aspect of the policy. The Board is anxious to ensure that boys who, after training, are to be employed underground are not kept on surface jobs for more than three months before starting their training. If they are put to work on the screens, they must only be kept long enough to enable them to distinguish readily between coal and dirt and to impress on them the waste of labour caused by sending dirt up the pit. It is also urged that, when their preliminary training is over, boys should be employed underground on a suitable sequence of jobs to widen their experience and promote their development, and that boys suitable for work at the face should be put to it as soon as they are fit for it.

The Board says that it has adopted the recommendations of the Gowers Committee on the hours of employment of young people. It says also that it intends soon to develop national apprenticeship schemes for mechanics and electricians and other colliery tradesmen. The leaflet adds that this policy for youth is intended to help the mining industry to get and to keep the boys it needs and to offer them satisfying work and a chance to get on.

Iron and Steel Distribution

The Minister of Supply, Mr. Duncan Sandys, stated in Parliament on Tuesday of last week that, subject to the continuance of the voluntary scheme for the distribution of steel plate, the Government was satisfied that it was no longer necessary for iron and steel to be rationed. Accordingly, it has been decided that, with the exception of tinplate, statutory control of the distribution of iron and steel should be brought to an end as from May 6th.

Mr. Sandys prefaced this announcement by saying that the output of iron and steel in general had been steadily increasing, mainly as the result of the completion of a number of new blast furnaces during recent months. It was expected that home production of steel this year would be about 17,500,000 ingot tons, which was about 1,300,000 tons more than in 1952. Whilst there would continue to be some shortage of steel plate, steel supplies as a whole were now considered to be sufficient to meet overall home demands, as well as to provide somewhat larger quantities for export. The satisfactory increase in home production, the Minister continued, should make it possible to reduce appreciably our imports of foreign steel. If, however, demand should rise further than was at present expected, there should not be much difficulty in purchasing additional steel from abroad.

Figures issued on Wednesday last by the British Iron and Steel Federation show that steel production in April was at the highest rate ever recorded for that month. The output of ingots and castings averaged 348,500 tons a week, which represents an annual production rate of 18,124,000 tons. This was slightly below the rate of production in March, but, of course, the effect of the Easter holiday must be taken into account. In April last year, steel production was at an annual rate of 15,866,000 tons. Pig iron production last month averaged 212,800 tons a week and was thus at an annual rate of 11,063,000 tons. A year ago pig iron output was at an annual rate of 10,472,000 tons.

The Cost of Exporting

In a statement circulated with the annual report of the United Glass Bottle Manufacturers, Ltd., the chairman, Mr. L. A. Elgood, comments on the cost of exporting. The statement recalls the setting-up, rather more than a year ago, of the Ports Efficiency Committee to consider ways and means of ensuring a quicker flow of traffic through the ports of the United Kingdom once goods were assembled for shipping. From the point of view of speed, Mr. Elgood comments, an overall decline in the volume of exports has resulted in delays in dispatch being so reduced that in the main goods, once ready, are now *en route* as quickly as was the case before the war. With the future in mind, the statement adds, these changed marketing conditions do not lessen the original purpose of the Ports Efficiency Committee. The cost of exporting from factories here to overseas ports, however, Mr. Elgood's statement continues, in no way compares with pre-war charges. For the maintenance of export trade, he says, that is an alarming condition.

Notes and Memoranda

Air and Water

ADMIRALTY TUG.—The Admiralty tug, "Samson," which is under construction at the Aberdeen yard of Alexander Hall and Co., Ltd., and is being engined by the same company, has a length of 180ft by 37ft beam, and was launched on May 14th, the naming ceremony being performed by Mrs. W. Watt Hepburn.

INSTITUTION OF NAVAL ARCHITECTS.—The Institution of Naval Architects has received and accepted an invitation from the Koninklijk Instituut van Ingenieurs to hold an autumn meeting in Holland. The meeting, which will take place at the Kurhaus, Scheveningen, will open on Monday, September 14th, and close on Friday, September 18th, and the provisional programme includes an official Government reception at The Hague, the reading of papers and visits to Amsterdam and Dordrecht.

DRY DOCK OWNERS AND REPAIRERS' CENTRAL COUNCIL.—At the annual general meeting, held in Edinburgh on May 6th, Mr. W. B. Johnstone, who is a director of Alexander Stephen and Sons, Ltd., was elected chairman of the Dry Dock Owners and Repairers' Central Council for 1953–54. Mr. A. C. Waddy, a director of William Gray and Co., Ltd., was elected senior vice-chairman, and Engineer Captain G. Villar, R.N. (Retd.), a director of John I. Thornycroft and Co., Ltd., was appointed junior vice-chairman.

A LONG TOW.—The tug "Castle Peak," which is operated by the Hong Kong Towage and Salvage Company, Ltd., and is powered by two British Polar diesel engines geared to one shaft, recently completed the towage of two ships from Sydney to Yokohama. The ships concerned were the cargo steamers "Dilga" and "Dundula," each of 5600 tons deadweight, and the method adopted was by means of separate tows, the steamers travelling on parallel courses at some distance apart. The distance of 4320 nautical miles was covered in thirty-eight days at an average speed of 4·5 knots.

REPAIR AND SERVICE LAUNCH.—Harland and Wolff, Ltd., has completed at Belfast a motor launch, "Harlandic II," for repair and service work at Southampton. The launch has a length of 60ft by 16ft beam and is propelled at 8 to 9 knots by a 120 b.h.p. diesel engine. There is a saloon forward and a sparred hold aft for the carriage of tools and repair materials, and the equipment includes lifesaving gear for thirty-six persons, searchlight, ship-to-shore radio telephone, and a towing bridle. The launch is available for vessels needing prompt repairs and for that purpose is fitted as a mobile workshop and there has been installed a diesel-driven generator, welding plant and air compressor.

Miscellanea

MR. C. HOPE LUMLEY.—We record with regret the death of Mr. Charles Hope Lumley, which occurred on April 29th. Mr. Lumley was a director of Sigmund Pumps, Ltd., Gateshead-on-Tyne.

WROUGHT ALUMINIUM ALLOYS.—A new brochure has been published by Imperial Chemical Industries, Ltd., Imperial House, Millbank, London, S.W.1, giving in convenient tabular form technical data on the "Kynal" and "Kynalcore" range of alloys. The information given is intended to assist designers and constructional engineers in the selection of suitable alloys.

FUEL DISTRIBUTION DEPOT.—Last week the new Sunderland terminal of the Vacuum Oil Company, Ltd., was officially opened. The installation has a storage capacity of over 1,000,000 gallons and will be supplied by coastal tanker from the company's refinery at Coryton in Essex. Three of the storage tanks, each with a capacity of 250,000 gallons, are built on the hemispheroid pattern with the contents held under pressure to avoid loss of volatile elements.

FERRYBRIDGE "B" POWER STATION.—The British Electricity Authority has received the consent of the Minister of Fuel and Power to the establishment of a new section of the Ferrybridge power station, Yorkshire, to be known as the Ferrybridge "B" station. It will have an installed capacity of 300MW, made up of three 100MW turbo-generators, each served by a boiler unit having an evaporative capacity of 755,000 lb of steam an hour. The existing station has an installed capacity of 170MW. Three cooling towers, each having a capacity of 4,000,000 gallons of water an hour, will serve the new section.

CONTINENTAL REFINERIES EXPANSION.—At several of the Continental refineries, owned by the Anglo-Iranian Oil Company, Ltd., and its associates, new plant is to be installed. At the Antwerp refinery a catalytic cracking plant and a catalytic polymerisation unit are to be added to improve the quality of the motor spirit. A new distillation unit will raise the capacity of the B.P. Hamburg refinery to 1,256,000 tons per annum, and the installation of a platformer of 250,000 tons a year capacity will assure the quality of the motor spirit. At the nearby Scindler refinery the introduction of a furfural treating plant will increase the output of high-quality lubricating oils, while a platformer, a twin to the Hamburg unit, will be added to the plant of the Dunkirk refinery.

HEAVY GOODS HANDLING IN RAILWAY YARDS.—A demonstration of handling railway containers and heavy goods with mobile cranes and a fork-lift truck made by Ransomes and Rapier, Ltd., was given at Ipswich goods yard on Friday, May 1st. It was attended by representatives of a number of firms particularly interested in handling timber and similar bulk goods in docks, yards, &c. First, one of the firm's 7 tons capacity mobile diesel-electric cranes was used to remove a 6-ton container from a high goods truck and load it on to a dray. It then proceeded to remove an awkward load in the form of a tree trunk, weighing just under 4½ tons, and transport it along the road. In each of these demonstrations the mobility and small turning circle of this design of mobile crane was used to the best advantage. In the demonstration with the fork-lift truck it was first shown in operation fitted with a cantilever jib in place of the forks. With this jib a container was removed from a truck, the tree trunk was unloaded and replaced on its wagons, and rough timber was handled. The jib was then removed in a few minutes to restore the unit for its normal fork-lift truck duties, which were then demonstrated with various kinds of loads. Following the demonstrations, the visitors were taken to the works of Ransomes and Rapier, Ltd., where they were shown the cranes, trucks and other products of the firm in course of manufacture. Demonstrations of the latest designs of lifting and handling equipment were afterwards given in the works yard, and the visitors were then invited to discuss their problems with the firm's engineers and designers.

COMMERCIAL CLASSIFICATION FOR COAL.—The United Nations Economic Commission for Europe has issued a report on a meeting of scientists, commercial experts and statisticians to prepare an international hard-coal classification system suitable for every-day commercial use. A detailed international scientific coal classification system was agreed upon last year. At a special meeting of the Commission's coal classification working party, proposals for a commercial system were submitted by France, Italy, The Netherlands and Poland. There was an exchange of views on the classification of coals by size and the scientists will now work on an international classification of coals by size on the basis of proposals put forward by the French and Swedish delegations and of the Polish standard system.

AUTOMATIC CASTING PROCESS FOR IRON GUTTERS.—For many years conventional sand moulding methods have been used for the manufacture of cast iron gutters, and in order to increase production a die casting process has been introduced by Federated Foundries, Ltd., of 75, Hawthorn Street, Glasgow, N, at one of its foundries. In this process a measured quantity of molten iron is ladled into a die made in the form of a channel of the required gutter length and shape. An upper mating die is then swung over to register in the channel die, and it imparts the required form to the inside of the casting after squeezing out the excess metal. The die assembly remains closed until the metal has set and then the upper die swings back for the gutter to be removed from the lower die. The whole casting process is automatically controlled from the time the metal is poured and signal lights on a control panel indicate to the operator the correct time for pouring and removal of the casting after the pressing operation. At the side of each casting machine is a fixture into which the gutters are transferred for the removal of flash from the edges.

TENDERS FOR THE SNOWY MOUNTAINS HYDRO-ELECTRIC PROJECT.—We learn from Reuters that Australia is to call for tenders from overseas contractors for part of the work in the second stage of the Snowy Mountains hydro-electric project. Senator William Henry Spooner, Minister for National Development, in making the announcement, said that over the next five years the Government planned to spend A£46,500,000 on the project, and a total of more than A£58,500,000 by 1961. The tenders needed immediately, he remarked, related to work on the Adaminaby dam. Part of this work costing A£16,000,000 would be done, he said, by the New South Wales Works Department. The rest would be by private contract. Tenders would be called for from Australia, North America, Britain and Europe. Separate tenders would be asked for a 14-mile tunnel with ancillary works, a 1½-mile pressure tunnel and surge shaft for Tumut Pond dam, and an underground power station, pressure shafts and tailrace tunnel. The Minister said it was expected that those making successful tenders would be able to start work next summer. All facilities such as access roads, living quarters, power for construction and administrative buildings would be provided by the Snowy Mountain Authority, so that the contractors could make a flying start, he added. The development plans for the Snowy Mountains were described in some detail in THE ENGINEER of June 10, 1949.

A ROLLING MILL SYMPOSIUM.—Delegates from eight European countries attended a symposium organised by British Timken, Ltd., and held in this country last week. The object of this symposium was to provide users of Timken bearings in rolling mills and other steel works plant with information about the application and handling of these bearings and to give them an opportunity to discuss them. In the course of the symposium visits were paid to the works of Richard Thomas and Baldwins, Ltd., and the Steel Company of Wales, Ltd. The following papers were presented and discussed:—"Handling and Maintenance of Timken Tapered Roller Bearings," by Mr. G. A. Bentley; "The Application of Timken Tapered Roller Bearings to Rolling Mill Roll Necks and Steel Works Plant," by Mr. W. P. Snedden; and "Extreme Pressure Greases for Roll Neck Bearings and the Testing of Their Film Strength," by Mr. J. H. Evans. The symposium concluded with a dinner in London on Friday, May 1st. In the course of his farewell speech to the delegates, Mr. F. J. Pascoe, the chairman and managing director of British Timken, Ltd., pointed out the difficulty in preparing anything like a fully comprehensive catalogue of the firm's products, which ranged from bearings weighing from $^1/_{16}$ oz to 3½ tons. The problem of deliveries had been seriously tackled by the company, which had spent not less than £3,500,000 during the past four years in increasing its productive capacity. A scheme now in hand envisaged the laying down of a complete new works at a cost of some £1,500,000.

Launches and Trial Trips

SILVERBROOK, oil tanker; built by Smith's Dock Company, Ltd., for the Silver Line, Ltd.; length between perpendiculars 500ft, breadth moulded 69ft 6in, depth moulded 38ft, deadweight 16,630 tons on 29ft 10½in draught, service speed 13 knots; twenty-seven cargo oil tanks, two pump rooms, three 500 tons per hour cargo oil pumps, two 100 tons per hour drain pumps; steam deck machinery; two 50kW steam-driven generators and one 25kW diesel-driven generator; Hawthorn-Doxford two-stroke oil engine, five cylinders 670mm diameter by 2320mm combined stroke, 5000 b.h.p. at 110 r.p.m.; two Scotch marine boilers.—Trial, April.

HOPEMOUNT, oil tanker; built at the Wallsend yard of Swan, Hunter and Wigham Richardson, Ltd., for the Hopemount Shipping Company, Ltd.; length between perpendiculars 526ft, breadth moulded 72ft 6in, depth moulded 40ft 6in, deadweight 19,010 tons, load draught 31ft 5½in, service speed 14·5 knots; twenty-seven cargo oil tanks, two pump rooms, four steam-driven horizontal duplex cargo oil pumps; steam deck machinery; two 75kW steam-driven generators, one 75kW diesel-driven generator; Wallsend-Doxford two-stroke oil engine, six cylinders 750mm diameter by 2500mm combined stroke, 8000 b.h.p. at 104 r.p.m.; two multi-tubular Scotch boilers. Trials, April 28th.

Personal and Business

MR. B. N. H. THORNELY has been appointed a director of Northern Aluminium Company, Ltd., Banbury.

MR. N. G. CADMAN, M.I.Mech.E., has been appointed works manager of Westinghouse Brake and Signal Company, Ltd.

MR. ARTHUR WOOD has been appointed a director of Henry Meadows, Ltd., Wolverhampton, and H. Widdop and Co., Ltd., Keighley.

MR. C. P. STORR, M.I.Mech.E., M.I.E.E., has been appointed power systems engineer of Metropolitan-Vickers Electrical Company, Ltd.

GEORGE KENT, Ltd., states that its factories at Luton, Resolven and London will be closed for the annual holiday from July 17th to August 4th.

DR. G. S. HISLOP, M.I.Mech.E., A.F.R.Ae.S., has been appointed chief designer in the helicopter division of the Fairey Aviation Company, Ltd., Hayes, Middlesex.

THE INTERNATIONAL MATERIALS CONFERENCE has announced that its address is now Room 837, Lafayette Building, 811, Vermont Avenue, N.W., Washington, 5, U.S.A.

PROABD (ENGLAND), Ltd., has been formed recently to undertake the design and manufacture of tar distillation and kindred plant. Its office is at Wheatsheaf House, Carmelite Street, London, E.C.4, the manager being Mr. A. F. Peart.

THE MIDLAND MOTOR CYLINDER COMPANY, Ltd., announces the retirement of Mr. G. F. Yorke after thirty-five years' service, during the last eight of which he has been joint managing director. Mr. F. A. W. Livermore has been appointed works director.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., states that Mr. Kenneth J. Clarke has been transferred from the Birmingham district office to the Sheffield office. Mr. J. Goldsmith is transferring from the company's London office to Birmingham.

MR. C. S. GARLAND, A.R.C.Sc., vice-chairman of the National Union of Manufacturers, who has represented the Crown for thirty years on the governing body of the Imperial College of Science, has been reappointed to represent the Queen for a further period of four years.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., announces that Mr. H. Boyd Brown, assistant to the chairman, has been appointed managing director of First Electric Corporation of South Africa. Mr. W. A. Ankerson has succeeded Mr. Boyd Brown as assistant to the chairman of A.E.I.

Contracts

THE British Electricity Authority has placed contracts during the past month for power stations, transformer stations and transmission lines amounting in the aggregate to £4,651,347. The principal contracts include: Brunswick Wharf power station, Poplar, circulating water pipework (Aiton and Co., Ltd.) and auxiliary cables and connections (London Electricity Board); Tilbury power station, two generator transformers (English Electric Company, Ltd.); Ince power station, near Ellesmere Port, superstructure (Holland, Hannen and Cubitts, Ltd.); Skelton Grange power station, Leeds, 11kV and lower-voltage cables and accessories (Drake and Gorham (Contractors), Ltd.); Stella North power station, near Newcastle upon Tyne, three reinforced concrete cooling towers and ancillary works (Davenport Engineering Company, Ltd.); Stella South power station, two brick chimneys (P. C. Richardson and Co.); Chadderton power station, Oldham, structural steelwork (Edward Wood and Co., Ltd.), and power, control and indication cables for two turbo-alternator sets (Enfield Cables, Ltd.); Huncoat power station, Accrington, brick chimney (P. C. Richardson and Co., (Middlesbrough), Ltd.); Wymondley substation, Herts, 132kV, 1500MVA switchgear (English Electric Company, Ltd.); Crumlin, Upper Boat and Ebbw Vale, uprating of 132kV, 1500MVA circuit breakers (Metropolitan-Vickers Electrical Company, Ltd.); and Iver-West Weybridge-Melksham, 275kV, twin 0·4 square inch, double circuit overhead lines (Balfour, Beatty and Co., Ltd.).

British Patent Specifications

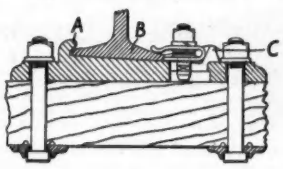
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

RAILWAY ENGINEERING

690,178. April 15, 1950.—Rail Fastenings, Guest, Keen and Nettlefolds (Midlands), Ltd., Cwmbran Works, Cwmbran, Monmouthshire. (*Inventor: William Augustus Jenkins.*)

Referring to the drawing, the invention is applied to the securing of a flat-bottomed railway rail. The base plate is provided at one side with an upstanding seating *A* engaging directly with the flange of the rail foot. The seating is recessed as indicated so as to locate the flange against both upward and lateral movement. Adjacent to the edge of the other flange *B* of the rail the base plate has a projection *C*, formed with an open-sided recess, the open side of the recess being directed towards the rail. One side of the projection *C* constitutes an abutment face inclined away from the rail in an upwards direction. The base plate has a fastening member in the form of a



No. 690,178

T-headed bolt secured within a recess and carrying the usual nut. Mounted on the bolt is a rail securing device in the form of a resilient metal clip of similar width to the recess, so that the clip when within the recess is prevented from turning about the axis of the bolt under rail creep. The bolt carries a spring washer and when the nut is tightened the end of the longer portion of the clip applies an increasing resilient downward pressure to the rail flange. At the same time the tightening of the nut tends to displace the connecting part of the clip downwards so that a wedging action occurs between the connecting part and the abutment face. This tends to displace the clip bodily in a horizontal direction towards the rail so that the end of the shorter portion applies an increasing lateral pressure to the edge of the rail flange, thus ensuring that the other flange is urged into tight engagement with the upstanding seating. Modified designs are also shown in the specification.—*April* 15, 1953.

METALLURGY

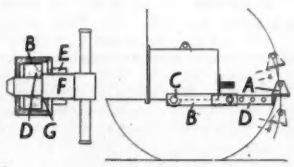
689,945. May 24, 1951.—Method of Observing Melting Processes by Determining the Black Body Temperature and the True or Colour Temperature, Siemens and Halske Aktiengesellschaft, Siemenostadt, Berlin, and Wittelsbacher Platz, 4 Munich, 2, Germany.

Melting and metallurgical processes have been observed by measuring the black body temperature by means of a disappearing filament pyrometer or a total radiation pyrometer and in addition the colour temperature. The true temperature has also been determined instead of the colour temperature, by means of thermocouples. This invention is based upon the principle of providing an indication by substantially simpler technical means by causing each electrical measurement value corresponding to the two temperatures, which is derived from a pyrometer of one of the kinds referred to, to act on a measuring instrument, the coefficient of emission and/or the quality of the melting process to be observed, being indicated by the point at which the needles of the two instruments intersect one another. The result obtained is that both the black body temperature and the colour temperature are conveniently indicated on a large, clearly visible indicating instrument and the point of intersection of the two needles clearly indicates the coefficient of emission and/or the quality of the melt.—*April* 8, 1953.

AGRICULTURAL ENGINEERING

690,157. July 31, 1951.—Draw Bar Devices for Tractors, Ateliers de Constructions Mecaniques de Vevey, S.A., Vevey, Switzerland. (*Inventor: Maurice Bonjour*).

According to the invention a draw bar device for tractors is provided with a frame supporting a draw bar member. The frame pivoted to a part at the rear of the tractor, is formed by two arms pivoting on the rear portion of the tractor in vertical planes. The free ends of the frame are connected by a transverse draw bar, the two arms being adjustable in length. The drawing shows the rear portion of a tractor in side elevation. The transverse member of the draw bar *A* forms a part of a frame formed by the two arms *B* and the shaft *C*, about which they pivot. The shaft is mounted on a portion of the rear part of the tractor. In order to allow adjustment of the transverse member *A* relatively to the rear part of the tractor, the two arms *B* are formed by box-section members of adjustable length. Each of these members is hinged at one of its ends to the shaft *C*. In the part *B* slides a part *D* formed by a



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rod of rectangular cross-section. This rod has apertures, similar to the part *C*. In order to maintain the two parts securely in the selected position, the face of the part *B* is provided around each transverse hole with a boss *E* with a threaded hole into which is screwed a pin *F* which has a shoulder *G* bearing against the edges of the hole of the inner rod to wedge it in the operating position. With the device it is possible to adjust the length of the arms of the draw bar. The mounting of the transverse member of the draw bar enables it to be removed in some cases so as to render the two arms independent for use with an alternative plough.—*April* 15, 1953.

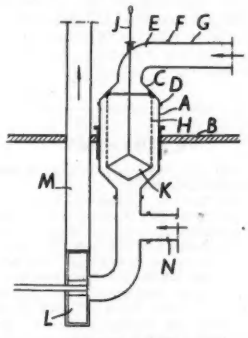
687,889. December 4, 1950.—Mowers for Attachment to Tractors, Featherstone Agricultural, Ltd., 59, Burnt Oak Broadway, Edgware, Middlesex. (*Inventor: Thomas William Henderson.*)

According to the invention, in order to prevent damage when the cutter-bar or other tool meets an obstruction, the bracing strut has a yieldable element which is adapted to relieve the load when the thrust applied to the strut exceeds a safe limit and allows the tool to move backwards relatively to the tractor when it meets an obstruction.—*February* 25, 1953.

CIVIL ENGINEERING

690,264. August 1, 1951.—Stone-Retaining Casing for Dredging Installations, J. and K. Smit's Scheepswerven N.V., Kinderdijk, The Netherlands.

The invention relates to stone-retaining casings for the protection of sand pumps in the hydraulic discharge of dredging installations on board barges or lighters used in dredging operations. Referring to the drawing, *A* is the body of the stone-retaining casing, which is encased in the deck *B* of the lighter or barge. The upper part or cap *C* is fixed to the body by a joint *D* by bolts. The cap is integral with an elbow *E* connected by a detachable joint *F* to the feed pipe *G* through which the mixture of water, sand and stones arrives. Suspended from the cap of the casing is a cylindrical grating or cage *H*. To the



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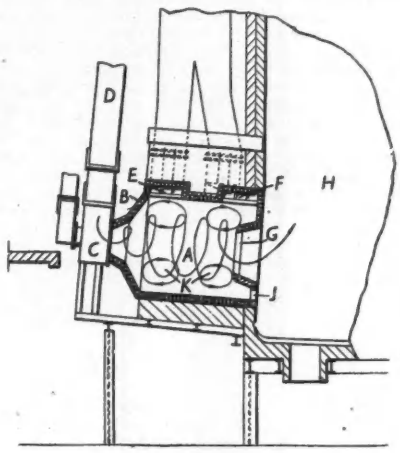
elbow *E* there is fixed a vertical tubular branch, through which passes a suspension rod *J* carrying at its lower end a movable bottom *K*. The lower part of the body is connected by an elbow to the sand pump *L* which discharges the water and the sand through the vertical pipe *M*. An auxiliary conduit *N* is adapted to introduce, in case of need, water for supply and for priming. In service the stones and other objects which are large enough are retained in the cage. When the cage is filled the joints are disconnected and the assembly transported to any suitable locality. By means of the rod the bottom is lowered to empty the cage.—*April* 15, 1953.

FURNACES

690,365. September 5, 1951.—Cyclone Furnaces, Babcock and Wilcox, Ltd., Babcock House, Farringdon Street, London, E.C.4.

An object of the invention is to avoid or reduce coke deposits by the introduction of additional air in the end regions of the furnace chamber. The drawing shows a sectional side elevation of a cyclone furnace and a part of a secondary combustion chamber. The cylindrical furnace chamber *A* is extended by a tapering transition piece *B* arranged to receive a rapidly whirling mixture of air and granular



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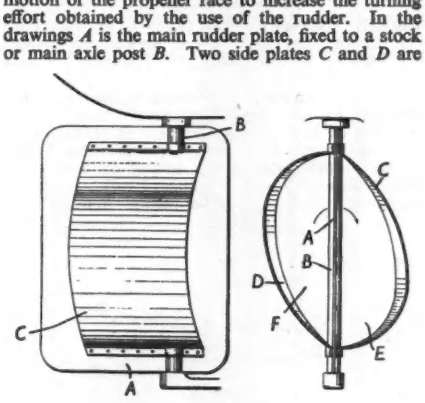
coal from fuel inlet chamber *C*. The mixture enters tangentially from a duct *D*. Discharging into front and rear regions of the furnace chamber are tangentially directed nozzles *E* and *F*, the widths of which are adjustable by means of plates pivoted at their outer ends. The gas outlet from the furnace chamber is formed by the tapering throat *G*, provided with cooling tubes and leading into a secondary combustion chamber *H*. At the bottom of the rear wall of the furnace chamber and extending between cooling tubes of that wall is a slag outlet *J* also leading to the secondary combustion chamber. During operation of the furnace chamber eddies such as *K* form in the end regions of the chamber and it will be seen that the inner parts of the eddies are directed away from the ends of the chamber.—*April* 15, 1953.

MARINE ENGINEERING

689,991. November 29, 1950.—Rudders for Tugs and Other Vessels, Edward George Jones, Brentside Wharf, Brentford Dock Road, Brentford, Middlesex.

The invention is designed to make use of the rotary motion of the propeller race to increase the turning effort obtained by the use of the rudder. In the drawings *A* is the main rudder plate, fixed to a stock or main axle post *B*. Two side plates *C* and *D* are



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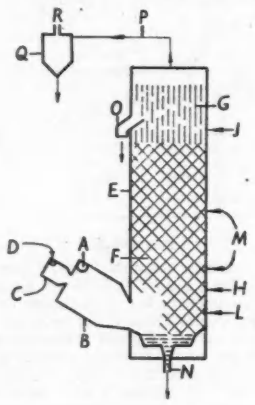
attached to the main plate, one on each side. Each side plate is curved approximately in the shape of a portion of an ellipse set with its major axis inclined to the axis of the rudder plate as viewed from fore and aft. Each of the waterways *E* and *F* between the main plate and the side plates is thus shaped in section like an oblique segment of an ellipse, the widest part of the waterway on one side being nearer the lower extremities of the side plates, whereas the widest part of the waterway on the other side is nearer the upper extremities of the side plates. The rudder shown in the drawing is intended for use with a right-handed screw propeller. For a left-handed screw the

curvatures of the side plates would be reversed. In the operation of the rudder with a right-hand rotating propeller the greater volume of water from the propeller stream is found at the top left and bottom right quarters of the propeller arc. Correspondingly, in the case of a left-hand rotating propeller, the greater volume or velocity of the propeller stream would be in the top right-hand and bottom left-hand quarters of the propeller arc. The construction described materially increases the power of the rudder and is particularly useful for tugs and other vessels in which great turning power is required.—*April* 8, 1953.

MINING ENGINEERING

690,214. December 29, 1948.—GASIFICATION OF FINE-GRAINED CARBONACEOUS SUBSTANCES, De Directie van de Staatsmijnen in Limburg, 2, van der Maesenstraat, Heerlen, The Netherlands.

The invention relates to process and installation for the gasification of fine-grained carbonaceous substances, such as fine coal, small coke, sawdust, and coal slime, usually called "dust gasification." The method according to the invention illustrated in the drawing provides that oxygen or a gas containing free oxygen, such as air, or air enriched in oxygen, is introduced at *A* into the small reactor *B*, which has the form of a cyclone. By means of a small feed cyclone *C* with an inlet opening *D* the material to be



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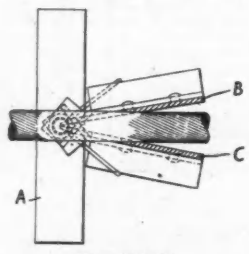
gasified is introduced into the reactor. In the large reactor *E* there is a column with filling bodies *F*, on the top of which is a "boiling bed" *G*. In this reactor the fine-grained substances to be gasified are supplied at *H* and/or *J*. The gases which contain oxygen are introduced at *L* and water vapour at *M*. The molten slag is drained off at *N* and the heavier particles leave the reactor at *O*. The gas mixture and the lighter particles are separated in the cyclone *Q*; the gas leaves at *R* and the lighter particles are returned into the feed cyclone at *D* together with the heavier particles.—*April* 15, 1953.

MISCELLANEOUS

689,837. November 12, 1949.—CLEANING WIRE ROPES, The Minister of Supply, Shell Mex House, London, W.C.2. (*Inventor: John Edward Whatmough.*)

The invention relates to a device for the mechanical cleaning of wire ropes. It may be used to clean a winch or haulage rope before it is coiled on the winding drum. As shown in the drawing, a rope to be cleaned before being wound on a winch is drawn through the square frame *A* which is suitably anchored. The rope passes within opposed slots



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in the blades *B* and *C*. The edges of these slots are tapered as shown and face the incoming rope and embrace a 90 degree arc, or more, of the circumference of the rope. In a modification mentioned in the specification a further set of blades is located with its hinge axis at 90 degrees to the first set of blades, the second set being supported by a second square frame. The positioning of the blade sets along the line of travel of the rope ensures that its whole periphery is scraped.—*April* 8, 1953.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24 Victoria Street, London, S.W.1.

LIMITS AND FITS FOR ENGINEERING: PART 1, "LIMITS AND TOLERANCES"

No. 1916, Part 1: 1953. Price 10s. net. This standard offers for the first time a system of limits and tolerances sufficiently comprehensive to cover every need from the watchmaker at one end to the heavy industries at the other.

The first standard to be issued on limits and fits for engineering was B.S. 164 : 1924, and this was reissued with some amendments in 1941. Whilst B.S. 164 was widely used in Great Britain it was far from comprehensive, and had little acceptance in other countries; for instance, European countries almost universally used some selection from the old I.S.A. (International Standards Association) system.

Committees of the B.S.I. have been investigating for some years past the possibility of providing a comprehensive system of limits and fits which would both be acceptable to British industry and which would also offer a basis for a universal standard. B.S. 1916, Part 1, is the result of this work and it makes available in inch measure the same range of fits, covering almost all the needs of engineering, as the I.S.A. system has long given to the Continental countries. Tables of metric equivalents are also included in this standard, for the benefit of those who have to work to metric measure, and the same method of designating fits is applicable to both systems of measurement.

A great many industries—the aircraft, electrical, gauge and tool, machine tools, railway, telecommunications and several others—were represented on the B.S.I. Committees, together with service departments and representatives of the Department of Scientific and Industrial Research. Over 2000 copies of the draft of the specification were circulated for comment to British, to Commonwealth and to U.S.A. organisations and firms; the replies contained much useful and detailed criticism, and, in the main, were enthusiastic for the new proposals. Close collaboration was maintained throughout with the U.S.A. and Canada, and it is confidently anticipated that within B.S. 1916 will be found the basis for an agreement between the British Commonwealth and the U.S.A.

The new specification supersedes B.S. 164, and it gives a choice of fits so wide that users should be able to make the transition from existing systems without undue difficulty. But to help users in applying the system to their own needs, and at the same time to encourage a greater degree of uniformity and interchangeability in the future than in the past, there is now in course of preparation Part 2 of B.S. 1916, which will give guidance in the use of Part 1 and offer recommendations and examples of the selection of fits.

PRIMARY CELLS AND BATTERIES FOR INTRINSICALLY SAFE BELL SIGNALLING CIRCUITS IN COAL MINES

No. 1975 : 1953. Price 2s. 6d. This standard deals with Leclanché primary cells and batteries which, in order to be "intrinsically safe," should be so constructed that the current is limited to a specified amount in order that the sparks produced in the signalling circuits are incapable of igniting inflammable gas. Full details of dimensions of the component parts, the composition of the electrolyte for wet cells, and requirements for the performance of complete cells are specified. The output of cells is limited to a figure which meets the requirements of the recognised testing authority, i.e. the Ministry of Fuel and Power.

Catalogues

MORRIS SPRINGS, Ltd., Ettingshall Road, Wolverhampton.—Stock spring catalogue No. 1.

W. G. PYE AND CO., Ltd., Granta Works, Newmarket Road, Cambridge.—Catalogue "H," scientific instruments.

PODMORES (ENGINEERS), Ltd., Shelton, Stoke-on-Trent.—Illustrated booklet dealing with vibro-electric equipment.

SANDERSON BROTHERS AND NEWBOULD, Ltd., Newhall Road, Sheffield.—Publication ME39, illustrating saws for wood.

BLAW KNOX, Ltd., 94, Brompton Road, London, S.W.3.—Publication BK-172/1, giving details of the BK-90 Scraper.

RICHARD KLINGER, Ltd., Klingerit Works, Sidcup, Kent.—Revised and enlarged "Level Gauge" section of catalogue.

ARCOLECTRIC SWITCHES, Ltd., Central Avenue, West Molesey, Surrey.—List No. 128, describing a range of switches and signal lamps.

FERRANTI, Ltd., Hollinwood, Lancashire.—Illustrated brochure containing a survey of the Ferranti foundry with some examples of its products.

MANCHESTER METAL WORKS, Ltd., 368–376, Bury New Road, Salford, 7.—Leaflets giving details of gap gauge blanks and special calipers.

B. ELLIOTT AND CO., Ltd., Victoria Works, Willesden, London, N.W.10.—Leaflet describing the "Progress" model 3 pillar drilling machine.

THE BELMOS COMPANY, Ltd., Bellshill, Lanarkshire.—Leaflets Nos. K.140, K.150, K.160 and K.170, describing industrial type contactor starters.

EDWIN DANKS AND CO. (OLDBURY), Ltd., Oldbury, near Birmingham.—Illustrated booklet showing the Oldbury "Minor" chain grate stoker.

CARTER GEARS, Ltd., Thornbury Road, Bradford.—Catalogue containing particulars of a range of hydraulic variable speed gears from ¼ h.p. to 22 h.p.

DONALD ROSS AND PARTNERS, Ltd., 1–3, Arlington Road, London, N.W.1.—Booklet introducing the "Twinner-Aronson" universal balance positioner.

BOWSER, MONKS AND WHITEHOUSE, Ltd., 45a, Market Place, Doncaster.—Folder containing details of a range of high-speed milling units and homogenizers.

HEENAN AND FROUDE, Ltd., Worcester.—Leaflets Nos. 129, dealing with hydraulic double-ram baling press for scrap metal and an all-geared triple-ram baling press for scrap metal.

THE TUDOR ACCUMULATOR COMPANY, Ltd., 137, Victoria Street, London, S.W.1.—Pamphlets showing the different applications of "Safetylyte" emergency lighting equipment.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., 21, Broomsbury Street, London, W.C.1.—Publication dealing with an all-insulated industrial wiring system, corrosion-resistant and waterproof.

CLAYTON CRANE AND HOIST COMPANY, Ltd., Irwell Chambers, East, Union Street, Liverpool, 3.—Booklet illustrating some Clayton overhead cranes in service in factories and workshops.

HOWARD CLAYTON-WRIGHT, Ltd., Wellesbourne, Warwickshire.—List No. HX20, illustrating a range of anti-vibration mountings designed for scientific instruments and light machinery.

STANDARD TELEPHONES AND CABLES, Ltd., Oakleigh Road, New Southgate, London, N.11.—Booklets describing the different types of control desks for telecontrol systems, and direct wire alarm systems.

DOWTY SEALS, Ltd., Ashchurch, Glos.—Catalogues entitled: "'Seloc,' the Leakproof Lock Washer," "Dowty Synthetic Rubber Seals," "'U' Section Gland Rings," and "'Strud,' the Leakproof Bolt."

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ILLUMINATING ENGINEERING SOCIETY

To-day, May 15th.—NOTTINGHAM CENTRE: E. Midlands Electricity Board, Smithy Row, Nottingham, Annual General Meeting, 6 p.m.

INCORPORATED PLANT ENGINEERS

Mon., May 18th.—LIVERPOOL BRANCH: Radiant House, Bold Street, Liverpool, Plant Maintenance Team's Visit to U.S.A., Report by Colin Troup, 7.15 p.m.

Tues., May 19th.—HERTS DISCUSSION GROUP: Peahen Hotel, St. Albans, "Sound Control in Industry," W. A. Hines, 7.30 p.m.

Wed. to Friday, May 20th to 22nd.—The Palace Hotel, Southport, Sixth Annual Conference.

Thurs., May 28th.—S. YORKSHIRE BRANCH: Grand Hotel, Sheffield, "New Developments in the Coal Mining Industry," 7.30 p.m.

Fri., May 29th.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Dust Control," R. J. Pitt, 7.30 p.m.

INSTITUTE OF ECONOMIC ENGINEERING

To-day, May 15th.—George Hotel, Church Lane, London, N.W.9, "Planning in Practice," P. M. Garnier, 7 p.m.

INSTITUTE OF NAVIGATION

To-day, May 15th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Navigation and Oceanography," G. E. R. Deacon and G. S. Ritchie, 5 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Wed., May 20th.—LONDON CENTRE: Visit to the Works of Black and Decker, Ltd., Harmondsworth, Middlesex, 2 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tuesday, May 19th.—ORDINARY MEETING: Great George Street, Westminster, London, S.W.1, James Forrest Lecture, "The Impact of Statistics on Civil Engineering," H. Levy, 5.30 p.m.

Thurs., May 21st.—N.W. ASSOCIATION: Engineers' Club, Albert Square, Manchester, Annual General Meeting, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Tues., May 19th.—MEASUREMENTS SECTION: Savoy Place, London, W.C.2, "Measurement with the Flying Spot Microscope," J. Z. Young, 5.30 p.m.

Wed., May 20th.—SUPPLY SECTION: Savoy Place, London, W.C.2, "The Utilisation of Solar Energy," E. C. Bullard, 5.30 p.m.

INSTITUTION OF GAS ENGINEERS

Tues. to Friday, May 19th to 22nd.—NINETEENTH ANNUAL GENERAL MEETING: Business Sessions will be held at Church House, Westminster, London, S.W.1.

INSTITUTION OF MINING AND METALLURGY

Thurs., May 28th.—Geological Society, Burlington House, London, W.1, Annual General Meeting, Part I, Corporate and Non-Corporate Members only, 4 p.m.; Part II, incorporating Presidential Address, J. A. S. Ritson, 5.15 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, May 15th.—STOKE-ON-TRENT SECTION: Building Department, N. Staffordshire Technical College, Cauldon Place, Shelton, Stoke-on-Trent, "Education for Industrial Management," T. U. Matthew, 7.30 p.m.

Tues., May 19th.—SHEFFIELD GRADUATES' SECTION: Royal Victoria Station Hotel, Sheffield, "Application of Tungsten Carbide Tooling," Mr. Brooke, 6.30 p.m.

Fri., May 22nd.—YORKSHIRE GRADUATE SECTION: Works Visit to Wm. Asquith, Ltd., High Road, Halifax, 6.45 p.m.

Wed., May 27th.—SHREWSBURY SECTION: Technical College, Shrewsbury, "Electronics as an Aid to Productivity," R. McKennell, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Thurs., May 21st.—Royal Technical College, Glasgow, Annual General Meeting, followed by "Engineering Aspects of the New Atomic Research Extension, University of Glasgow," D. M. Hamilton and J. Hardie Glover, 5.30 p.m.

INSTITUTION OF WATER ENGINEERS

To-day, May 15th.—Palace Hotel, Southend-on-Sea, Fifty-Eighth Summer General Meeting.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., May 26th.—Manson House, Portland Place, London, W.1, Annual General Meeting, 6 p.m.; "The Instrumentation of Pilot and Experimental Scale Plant," W. A. Goldstein, 7 p.m.